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PRESSURE DATA FROM A 64A010 AIRFOIL AT TRANSONIC SPEEDS IN HEAVY GAS MEDIA OF RATIO OF SPECIFIC HEATS FROM 1.67 to 1.12

(NASA-TM-X-62468) PRESSURE DATA FROM A 64A010 AIRFOIL AT TRANSONIC SPEEDS IN HEAVY GAS MEDIA OF RATIO OF SPECIFIC HEATS FROM 1.67 TO 1.12 (NASA) 290 p HC $8.75 CSCL 01A

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Anthony R. Gross and Frank W. Steinle, Jr.

Ames Research Center
Moffett Field, California 94035

August 1975

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16. Abstract

ABSTRACT

A NACA 64A010 pressure-instrumented airfoil has been tested at transonic speeds over a range of angle of attack from -1 to 12 degrees at various Reynolds numbers ranging from 2 to 6 million in air, argon, Freon 12 and a mixture of argon and Freon 12 having a ratio of specific heats corresponding to air.

Good agreement of results is obtained for conditions where compressibility is not significant and for the air and comparable argon-Freon 12 mixture. Comparison of heavy gas results with air, when adjusted for transonic similarity, show improved, but less than desired agreement.

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Ames Research Center

SUMMARY

A wind tunnel investigation has been performed at Mach numbers from 0.6 to 0.9 to determine the wake drag characteristics and pressure distributions of a NACA 64A010 airfoil in air and in heavy gas test media with ratio of specific heats (γ) from 1.67 to 1.12. The model was tested at angles of attack from -1 to 12 degrees over a range of chord-based Reynolds numbers from 2×10^6 to 6×10^6.

Analysis of test results shows good agreement between data derived in air and data derived in heavy gases up to the Mach number at which compressibility effects become important in air. Above this Mach number agreement is encouraging but not completely resolved. Application of established theory for transonic similarity to the heavy gas results produces significant, but less than satisfactory, improvement in agreement. Data obtained in air and in an argon-Freon 12 gas mixture designed to have a $\gamma = 1.4$ show generally good agreement throughout the Mach number range of investigation.

INTRODUCTION

Within the past decade, severe problems (both technical and economic) have been encountered in predicting the aerodynamic characteristics of modern, high subsonic and transonic speed aircraft from wind tunnel test results extrapolated to flight Reynolds number. These differences have been largely attributed to deficiencies in the scaling of the viscous boundary layer on the wind tunnel models and uncertainties of modeling the behavior of the shock-boundary layer interaction as the "Reynolds number gap" between tunnel and flight is widened. Recently, considerable effort has been expended towards developing increased high Reynolds number test capability. Included in these efforts are new test techniques, improved wall-interference computations, construction of new test facilities, and the use of heavy gases in existing facilities.

The modification of existing facilities to use heavy gases, such as Freon 12, in place of air has the attraction of increasing the Reynolds number about three-fold at half the drive power for a given Mach number

and total pressure. For example, this would produce a potential increase in Reynolds number per meter of from 26.25 million to 78.75 million at a Mach number of 0.9 in the Ames Research Center's 2- by 2-Foot Transonic Wind Tunnel.

Whereas static aerodynamic data obtained in Freon 12 at subcritical conditions has been shown to be aerodynamically reliable, there is reason to believe that at transonic speeds the deviation of the ratio of specific heats (γ) from that of air (γ = 1.12 and 1.4, respectively) results in an adverse effect on data reliability (reference 1). In order to investigate this assumption, a NACA 64A010 airfoil model has been tested at transonic speeds at Mach numbers from 0.6 to 0.9 in heavy gas media of γ from 1.67 to 1.12. Wake drag characteristics and pressure distributions have been determined for the model for angles of attack from -1 to 12 degrees over a range of chord-based Reynolds numbers from 2×10^6 to 6×10^6.

Presented herein are the results of this investigation with a minimum of analysis.

NOMENCLATURE

Because of the limitations in the computer notation system for plotting the data, conventional aerodynamic symbols have been replaced by plot symbols in the data figures as noted below.

Symbol	Plot Symbol	Definition
c		airfoil chord, m
C_D	CD	drag coefficient, drag per unit span/qc
$C_{D_{(C_L = 0)}}$	CDCLO	drag coefficient at zero lift coefficient
C_L	CL	lift coefficient, lift per unit span/qc
C_{L_α}	CLALFA	derivative of lift coefficient with respect to alpha at zero lift coefficient
C_m	CLM	pitching moment coefficient, pitching moment per unit span/qc^2
C_p	CP	pressure coefficient, $\frac{p_1 - p_\infty}{q}$

K		transonic similarity scaling factor
M	MACH	freestream Mach number
M_a		Mach number in air
M_{ts}		air-equivalent Mach number, from application of the transonic similarity rule
p		static pressure, N/m^2
q		freestream dynamic pressure, N/m^2
Rn/c	RN	Reynolds number based on chord, million
x		coordinate measured parallel to airfoil chord, m
t		maximum airfoil thickness, m
α	ALPHA	angle of attack, deg
γ	GAMMA	specific heat ratio
τ		airfoil thickness ratio, t/c

Subscripts

l	local
∞	freestream
2	heavy gas medium

TEST FACILITY

The Ames 2- by 2-Foot Transonic Wind Tunnel is of the closed-return, variable-density type with a 0.61-meter (2-foot) square test section (figure 1). The tunnel drive system is composed of a two-stage axial-flow compressor driven by four 1000-horsepower water-cooled induction motors. The test section has variable-permeability, 21% open porous-slotted walls with a surrounding plenum chamber and suction provided by both a 2.365 and 11.815 $meter^3$ per second (5,000 and 25,000 cubic feet per minute) compressor. A flexible-wall nozzle is located upstream of the test section.

Continuous variation of the test section Mach number from 0 to 1.4 is provided through control of the main drive compressor speed and adjustment of both the flexible nozzle walls and the floor-to-ceiling angle. The tunnel stagnation pressure range is variable from 1/3 to 3 atmospheres absolute. Maximum Reynolds number available in air is approximately 26.25 x 10^6/meter (8 x 10^6 per foot) at a test section Mach number of 0.9.

This facility has undergone several modifications to permit two-dimensional testing and for this investigation, to permit testing in gas media other than air. These modifications include the addition of motorized, rotating, thick-glass, model supporting side windows mounted in unventilated, plane side walls, the incorporating of a programmable wake survey rake system, and the addition of a heavy gas system. The heavy gas system includes provisions for separating the heavy gas from the main axial fan and motor bearing lubrication system, for heavy gas supply and venting, and for measuring gas mixture properties.

MODEL DESCRIPTION

The model tested in this investigation was a NACA 64A010 airfoil which spanned the test section. The .1524 meter (6-inch) chord model was instrumented with 24 pressure orifices on the upper surface and 22 orifices on the lower surface. Airfoil ordinates and orifice locations are tabulated in table 1. An installation photograph of the model and the wake survey rake is shown in figure 2.

TESTING AND PROCEDURE

Air, argon, Freon 12, and a mixture of argon and Freon 12 were used as the various test media to provide for γ values of 1.4, 1.67, 1.12 and 1.4, respectively. The matrix of test conditions is presented in table 2. Test conditions spanned sub-critical, critical and super-critical Mach numbers for the airfoil.

Boundary layer transition to turbulent conditions on the model was artifically induced through the use of 0.254 mm (0.01 inch) wide strips of 0.104 mm (0.0041 inch) nominal diameter glass beads placed on the upper and lower surfaces at the 6.1 percent chord station. Bead diameter was selected in accordance with the recommendations of reference 2. Transition strip effectiveness was verified through the sublimation technique.

Angle of attack variation was accomplished by rotating the windows in the test section side walls to which the model was attached. The model was aligned with the flow to produce C_L = 0 at zero angle of attack.

Three 24-port scanning valves were used to measure the model surface pressures and three 48-port scanning valves were used to measure the total and static pressures in the wake. Wake total and static pressures were sensed through the use of an 82-tube traversing rake which was programmed to provide total pressure readings every 1.3 mm (0.050 inch) and static pressure readings every 25.4 mm (1.0 inch) across the wake of the model.

DATA REDUCTION

In addition to the customary stagnation temperature and pressure and the test-section static pressure measurements, the determination of the test gas composition which is necessary for calculation of the wind tunnel flow parameters requires measurement of total gas density, air content (determined by oxygen content) and water vapor content. Additional instrumentation was developed for these nonstandard measurements.

The wind tunnel test mixture composition is determined from direct measurements of air and water vapor fractions and computed fractions of argon and Freon 12. These computations are based on the total gas density measurement, adjusted for air and water vapor, and the virial form of the equation of state for argon and Freon 12. Estimated accuracy is ± 1.0%.

Significant real-gas effects associated with the use of Freon 12 as a wind tunnel test medium preclude the use of the normal ideal gas model for the computation of flow parameters. The van der Waals gas model was chosen instead to model the non-ideal gas properties for the calculation of flow parameters.

Section aerodynamic force and moment coefficients are obtained from the model surface and momentum rake measurements in the normal manner for two-dimensional airfoils. Pressure integrations were performed using the trapezoidal rule.

The two-dimensional transonic similarity rule of von Karman, in a form due to Spreiter (ref. 3), has been used to compare test results obtained in Freon 12 with those obtained in air. For the present case of an airfoil tested in air and in a heavy gas medium, the Mach numbers for transonic similarity in the heavy gas are determined from the following relation:

$$\frac{1 - M_a^2}{(2.4\ M_a^2)^{2/3}} = \frac{1 - M_{ts}^2}{\left[(\gamma_2 + 1)\ M_{ts}^2\right]^{2/3}}$$

The pressure coefficient $C_{p_{ts}}$ (C_p obtained at M_{ts}, γ_2) is then scaled to the reference C_p condition in air in accordance with

$$C_p = K\, C_{p_{ts}} \qquad \text{where } K = \left[\frac{(\gamma_2 + 1)\ M_{ts}^2}{2.4\ M_a^2}\right]^{1/3}$$

Values of M_{ts}, and the corresponding values of K, for several values of γ_2 and M_a are listed in table 3.

Based on transducer performance and on the estimated accuracy in mixture composition (1%) the precision of the data is estimated to be within

γ	$\pm$	.03	C_p	$\pm$	.0064
M_∞	$\pm$	.009	α	$\pm$	.06°

RESULTS AND DISCUSSION

A complete index to the data figures is given in table 4. Because the argon/Freon 12 test gas media was contaminated during tunnel operation by significantly varying amounts of air, γ varied somewhat from the respective 1.67 and 1.12 values. Tabulated in table 5 is a list, by data set and Mach number, of the computed values of γ corresponding to the plotted test results. Basic pressure and section coefficient data are presented in figures 3 through 10. In the following discussion attention is centered primarily on the comparison data presented in figures 11 through 14 and the summary comparisons given in figure 15.

As shown in figures 11 and 12, at subcritical Mach numbers the agreement between pressure distribution data for the non-lifting condition acquired in air and corresponding data from the heavy gas media is quite good. However, some differences in the pressure distribution over the aft portion of the airfoil are evidenced between data derived in air and argon. These differences may be due to slight differences in boundary layer development and/or lift.

The comparison of air and argon data in figure 11 at the supercritical Mach numbers .832 and .829, respectively, shows very good agreement. On the basis of transonic similarity this agreement is somewhat perplexing since, from table 3, the argon data would be expected to be very similar to air data at Mach number .838. With this in mind, an examination of the variation of drag with Mach number (figure 15) would lead one to expect C_D to be at least .003 higher in argon than in air.

However, comparison of the drag measurements reveals considerably less than .003. The reason for this discrepancy has yet to be determined. The pressure data in figure 11 appear as if Mach number.829 in argon is the air equivalent Mach number .832. This would require γ to be of the order 1.5 as compared with the measured value, 1.616. It is felt that such a difference is outside the range of experimental error. An alternate and more likely possibility is wall interference effects altering the pressure distribution. Some inference to this possibility can be drawn from the variation of lift-curve slope with Mach number, presented in figure 15. Lift-curve slope peaks near Mach number .82 and rapidly falls off with increasing Mach number to near zero. This abrupt change, in part, may be due to the sonic-line reaching the tunnel boundary and therefore changing its character. Obviously, such a postulation will require further verification before it can be accepted and therefore the above discrepancy between air and argon remains unresolved.

The comparison in figure 12 of air and Freon 12 data at Mach numbers .820 and .823, respectively, shows considerable differences. It is inferred that these differences are primarily due to γ effects. Because data in Freon 12 were not obtained at the transonic similarity Mach number for air at Mach number .820, it is not possible to verify γ effects on a direct basis. However, at Mach numbers .832 and .843 for air and Freon 12, respectively, a comparison on the basis of transonic similarity is available in figure 13a which supports this contention.

As can be seen, the general agreement of the air and Freon 12 results on an as-run basis at transonic similarity Mach number conditions is considerably improved. Further adjusting the test results to account for the full effects of transonic similarity is seen in figure 13b to afford only slight improvement.

The comparison of data obtained in air and in an argon-Freon 12 mixture having a ratio of specific heats equal to that of air at closely similar test conditions (example, figure 14) shows generally good agreement.

CONCLUDING REMARKS

A NACA 64A010 pressure-instrumented airfoil has been tested at transonic speeds over a range of angle of attack from -1 to 12 degrees at various Reynolds numbers ranging from 2 to 6 million in air, argon, Freon 12, and a mixture of argon and Freon 12 having a ratio of specific heats corresponding to air.

Good agreement of results is obtained for conditions where compressibility is not significant and for the air and comparable argon-Freon 12 mixture. Comparison of heavy gas results with air, when adjusted for

transonic similarity, show improved, but less than desired agreement. It is anticipated that further improvements in heavy gas-air agreement will be realized through the use of numerical transonic computations coupled with suitable boundary layer calculations to account for differences in displacement thickness producing different effective airfoil thickness.

REFERENCES

1. Treon, Stuart L.; Hofstetter, William R.; and Abbott, Frank T.: "On the Use of Freon 12 for Increasing Reynolds Number in Wind Tunnel Testing of Three-Dimensional Aircraft Models at Subcritical and Supercritical Mach Numbers". AGARD Paper CP-83-71, 1971.

2. Braslow, Albert L.; Hicks, Raymond M.; and Harris, Roy V., Jr.: Use of Grit-Type Boundary-Layer-Transition Trips on Wind-Tunnel Models. NASA TN D-3579, 1966.

3. Liepmann, Hans W.; Roshko, Anatol: Elements of Gasdynamics, John Wiley and Sons, Inc., New York, 1960, PP 256-258.

TABLE 1. - MODEL GEOMETRY

AIRFOIL ORDINATES

Station	Ordinate
0	0
.5	.804
.75	.969
1.25	1.225
2.5	1.688
5.0	2.327
7.5	2.805
10	3.199
15	3.813
20	4.272
25	4.606
30	4.837
35	4.968
40	4.995
45	4.894
50	4.684
55	4.388
60	4.021
65	3.597
70	3.127
75	2.623
80	2.103
85	1.582
90	1.062
95	.541
100	.021

L.E. radius: 0.687 percent chord
T.E. radius: 0.023 percent chord

STATIC PRESSURE ORIFICE LOCATIONS

Station	
Upper	Lower
0.0	1.2
1.0	2.5
2.3	5.1
5.0	7.5
7.4	10.1
9.9	15.0
14.9	20.0
19.8	25.2
24.9	30.0
30.0	35.1
34.9	40.1
39.9	45.0
44.9	50.1
49.9	55.0
54.9	60.1
59.9	65.0
65.0	70.1
70.0	75.0
74.9	80.0
79.9	85.0
84.9	89.9
90.0	94.5
93.2	
100.0	

(Airfoil dimensions are given in percent of airfoil chord)

TABLE 2. - MATRIX OF TEST CONDITIONS

Gas Medium	Air	Argon	Freon 12	Argon-Freon 12
Gamma (Nominal)	1.4	1.67	1.12	1.4
Reynolds Number x 10^6	2.0, 2.5, 3.0, 3.45, 3.75, 4.0	2.0, 3.0, 4.0	3.0, 6.0	2.0, 3.0
Mach Number range	0.6 to 0.9	0.6 to 0.85	0.6 to 0.85	0.6 to 0.85
Angle of Attack range, degrees	-1 to 12	-1 to 12	-1 to 12	0 and 2

TABLE 3. AIR EQUIVALENT TRANSONIC SIMILARITY VALUES

γ_2	M_a	K	M_{ts}
1.125	0.5	.986	0.5203
	0.6	.983	0.6196
	0.7	.975	0.7172
	0.8	.970	0.8129
	0.9	.966	0.9072
1.300	0.5	.995	0.5071
	0.6	.995	0.6069
	0.7	.991	0.7061
	0.8	.989	0.8046
	0.9	.989	0.9026
1.500	0.5	1.004	0.4932
	0.6	1.008	0.5935
	0.7	1.007	0.6941
	0.8	1.009	0.7955
	0.9	1.012	0.8975
1.667	0.5	1.012	0.4825
	0.6	1.017	0.5827
	0.7	1.019	0.6847
	0.8	1.025	0.7882
	0.9	1.031	0.8934

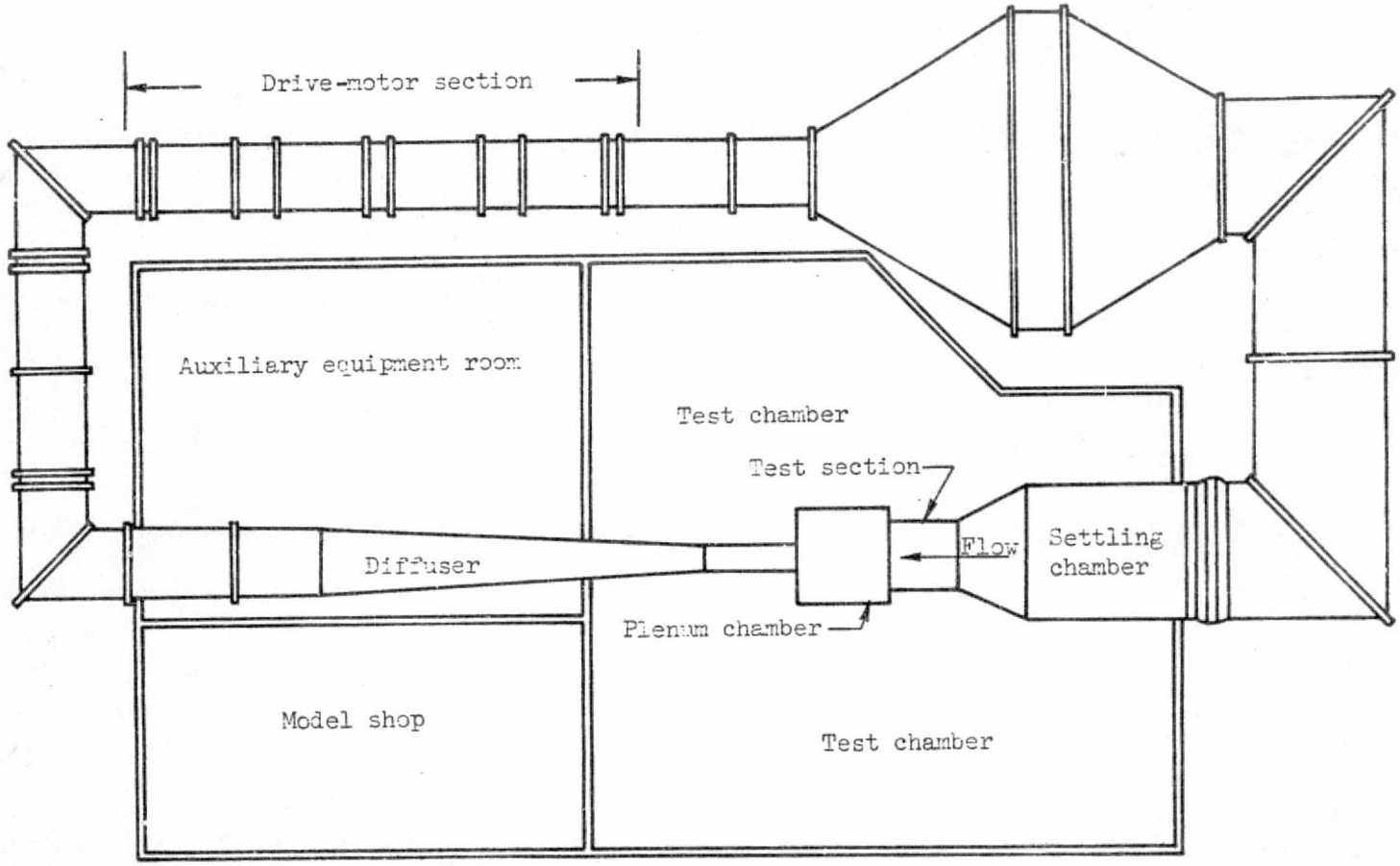
TABLE 4. - INDEX OF DATA FIGURES

Basic Data

Comparison Data

TABLE 5. TESTED VALUES OF THE RATIO OF SPECIFIC HEATS

DATASET	MACH	GAMMA
14	0.598	1.58
	0.610	1.62
	0.816	1.55
	0.823	1.54
	0.839	1.55
	0.844	1.55
	0.868	1.54
	0.874	1.56
15	0.603	1.62
	0.785	1.67
	0.820	1.57
	0.829	1.62
	0.877	1.55
16	0.608	1.63
	0.865	1.61
22	0.602	1.43
	0.802	1.39
	0.820	1.40
	0.852	1.39
23	0.602	1.38
	0.817	1.38
	0.822	1.39
	0.851	1.39
24	0.593	1.11
	0.801	1.11
	0.807	1.10
	0.843	1.13
25	0.599	1.12
	0.618	1.12
	0.786	1.12
	0.808	1.12
	0.813	1.12
	0.824	1.12
	0.851	1.12
	0.895	1.12
26	0.823	1.12



Test section configuration:	0.61m x 0.61m (2 ft x 2 ft) Adjustable baffled slots, floor and ceiling. Motorized, rotating thick glass discs for full span model mounting. Schlieren capability.
Mach number range:	0.6 to 0.95 in two-dimensional configuration (continuously variable).
Reynolds number range:	Approximately 0.5×10^6 to 4×10^6 based on 15.2 cm (6 in.) chord (pressure variable).

Figure 1. - NASA Ames Two -by Two-Foot Transonic Wind Tunnel Circuit and Specifications.

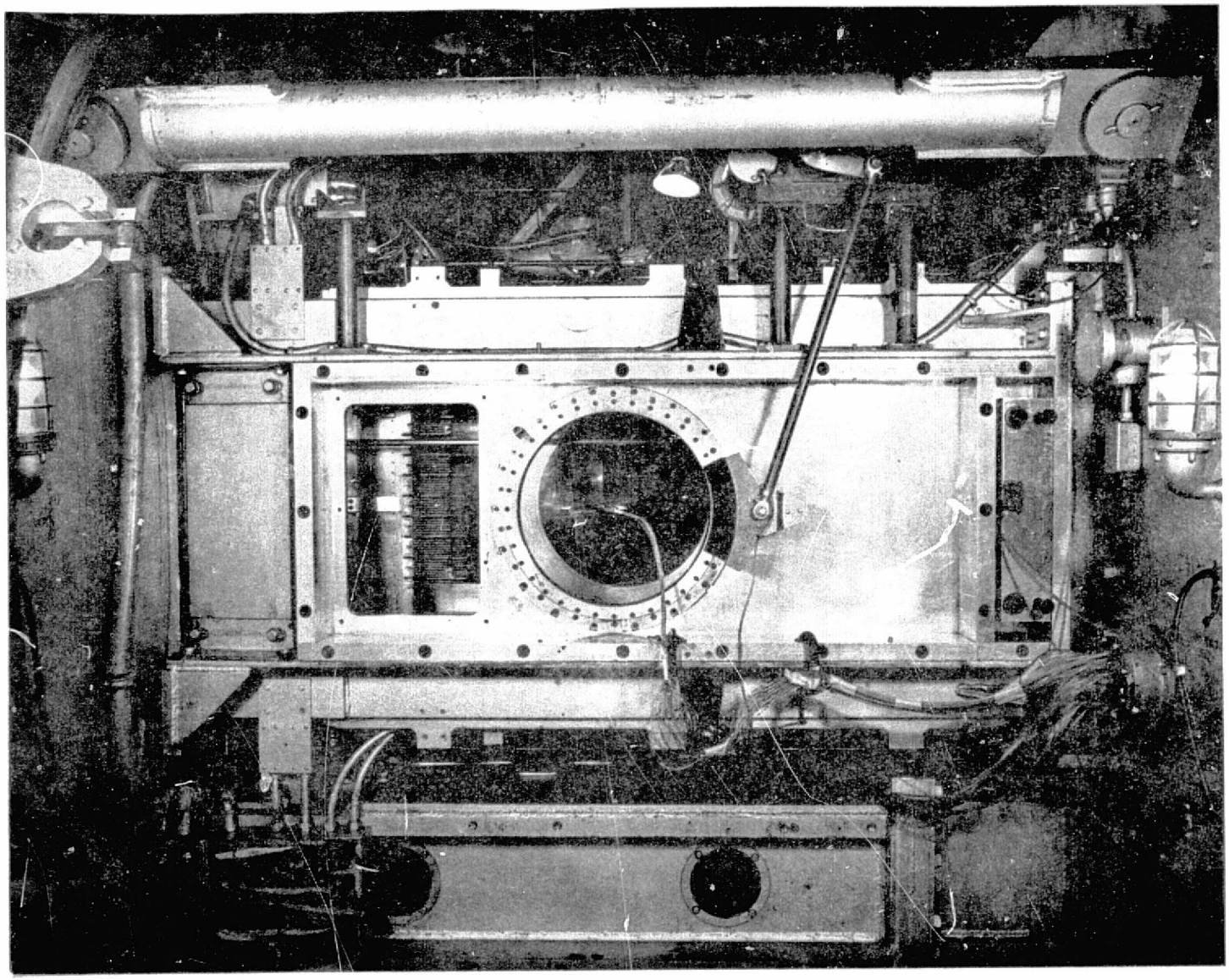


Figure 2. - Model Installation Photograph.

DATA

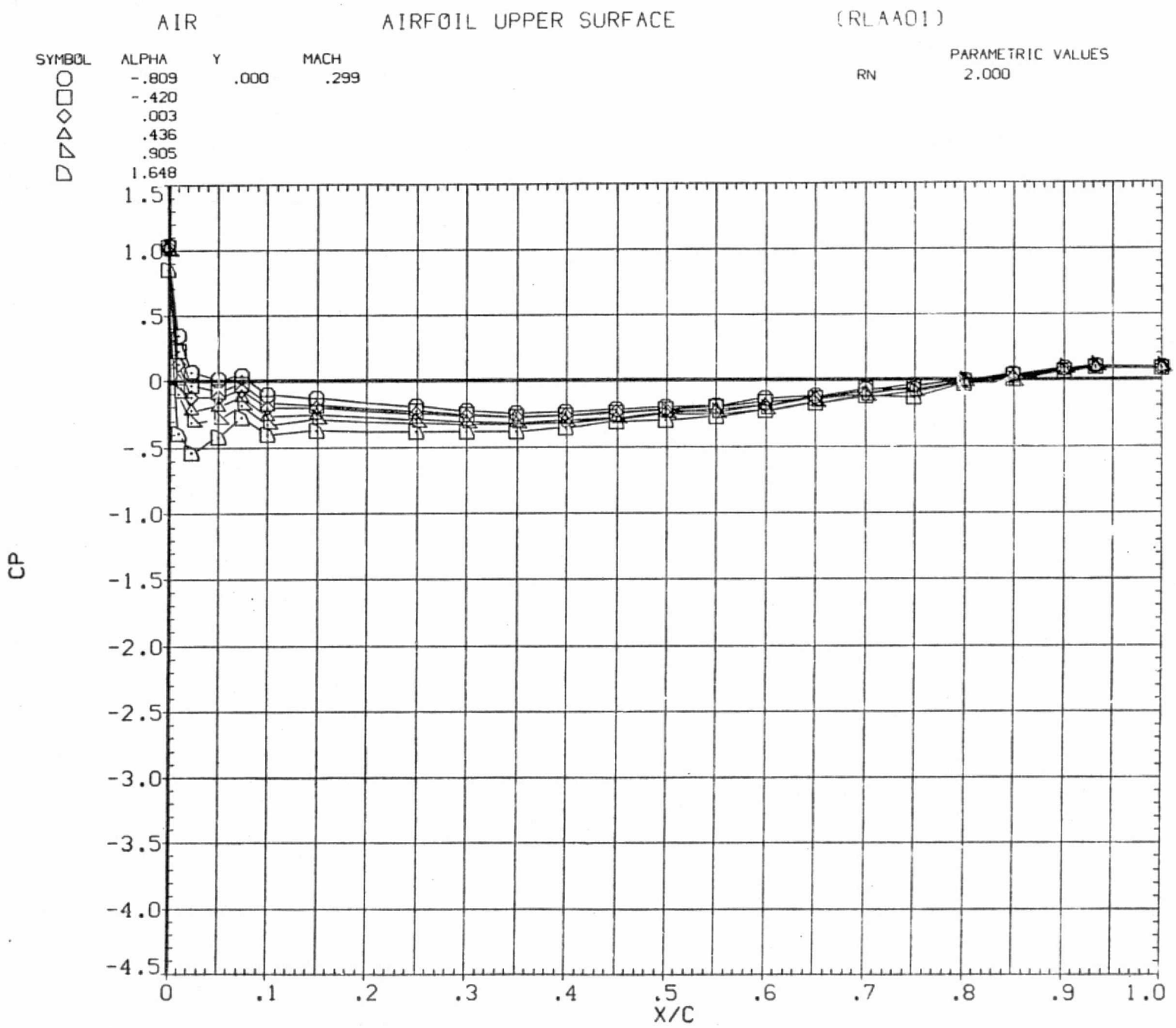


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

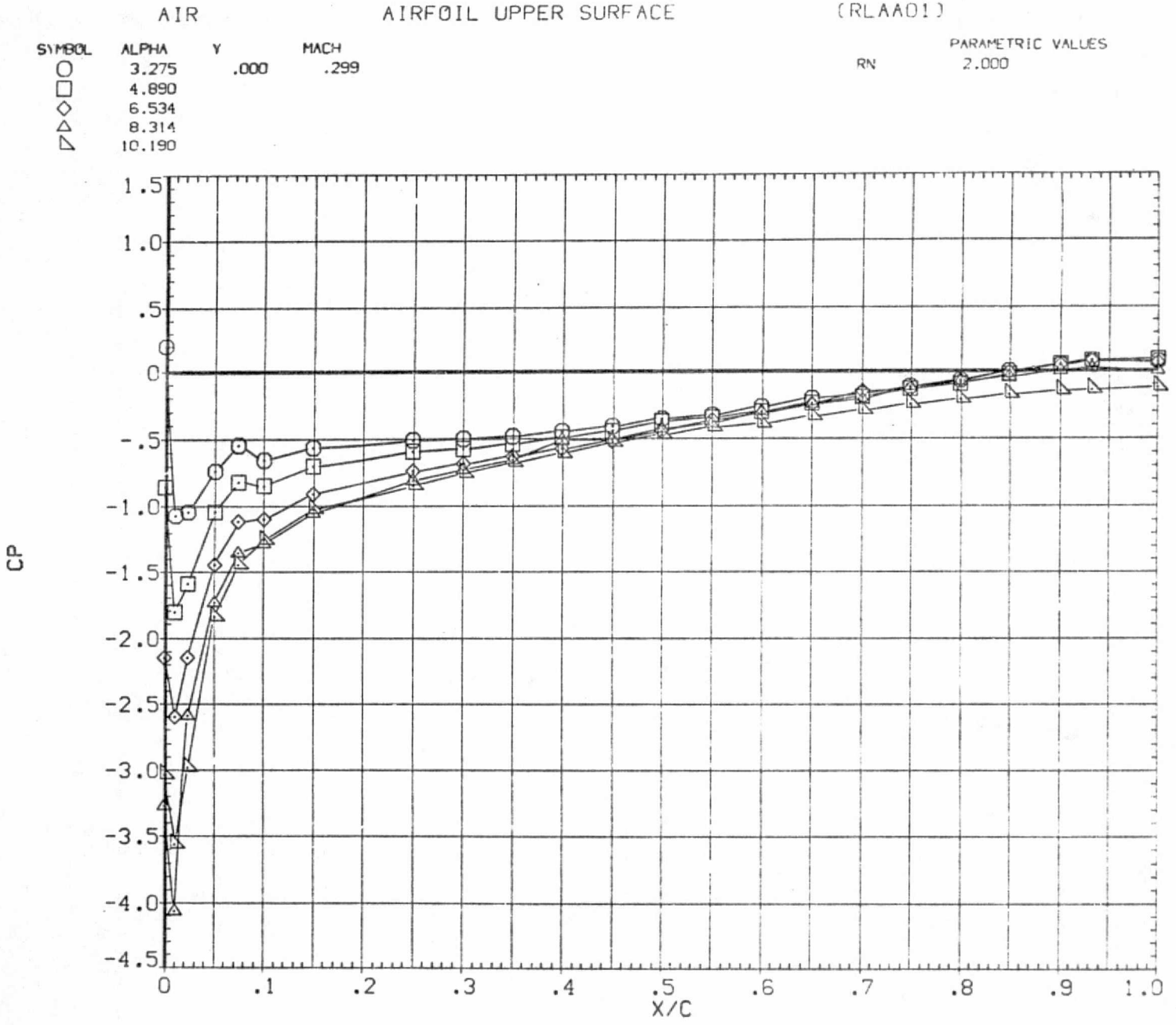


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

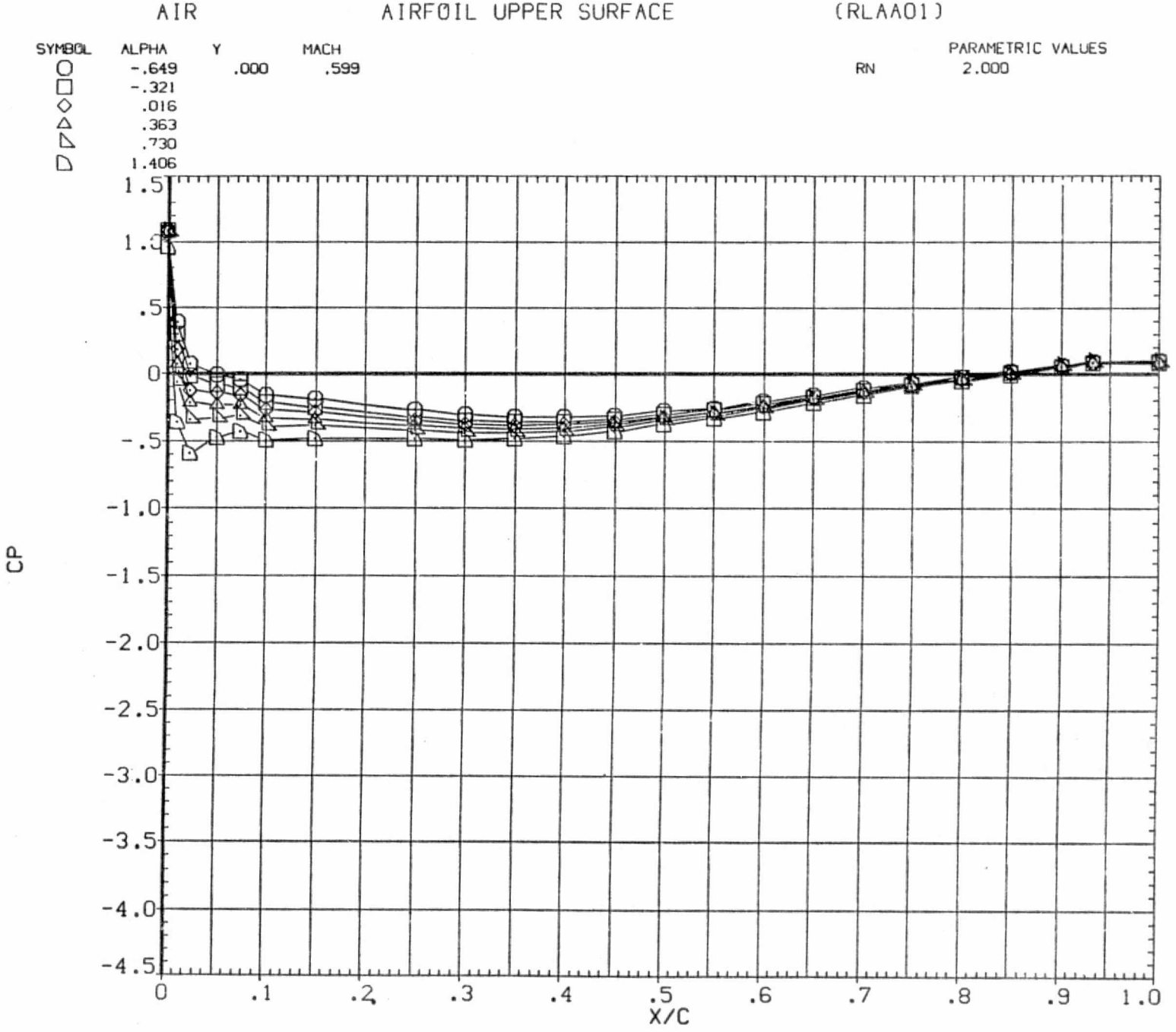
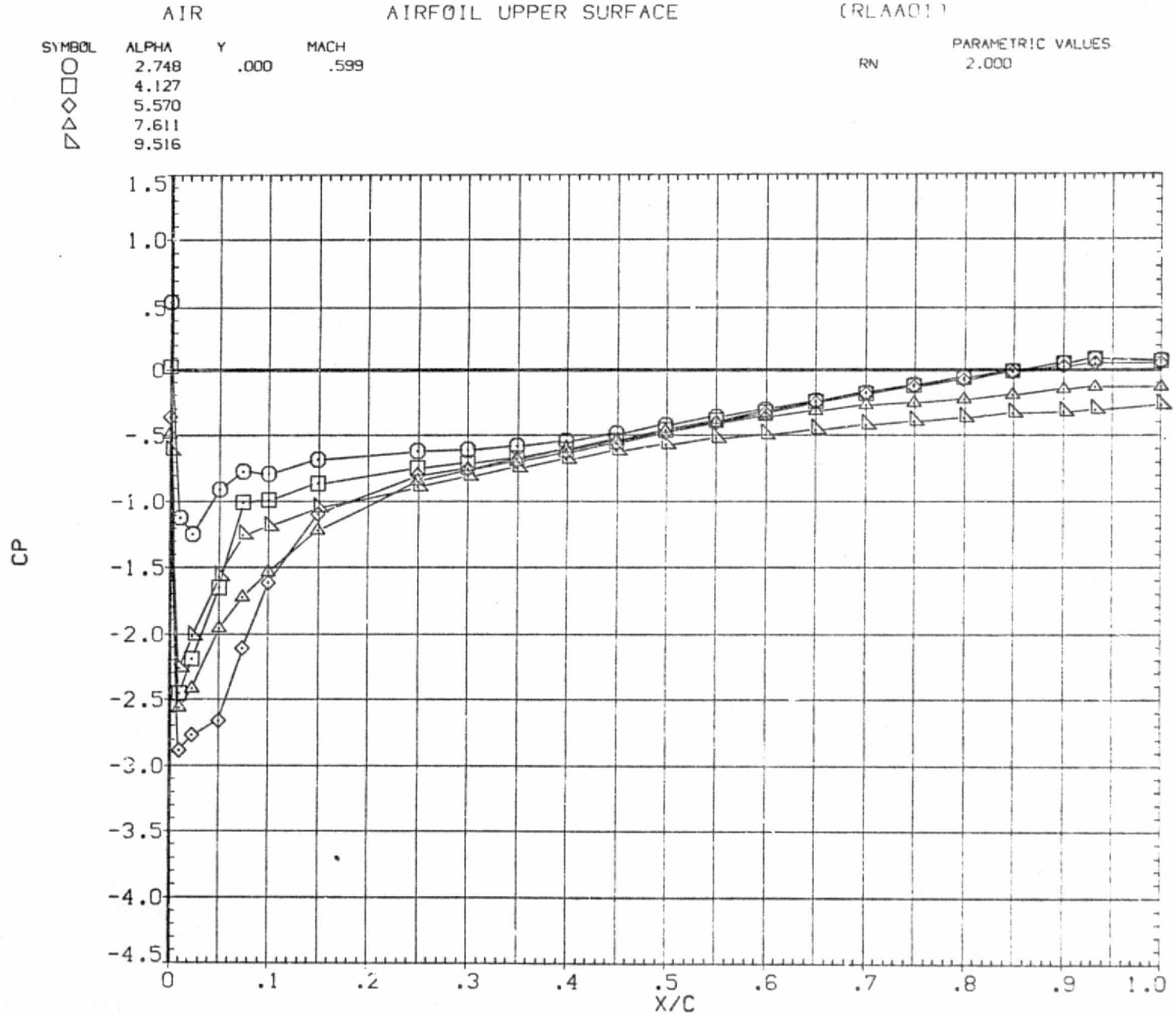


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR



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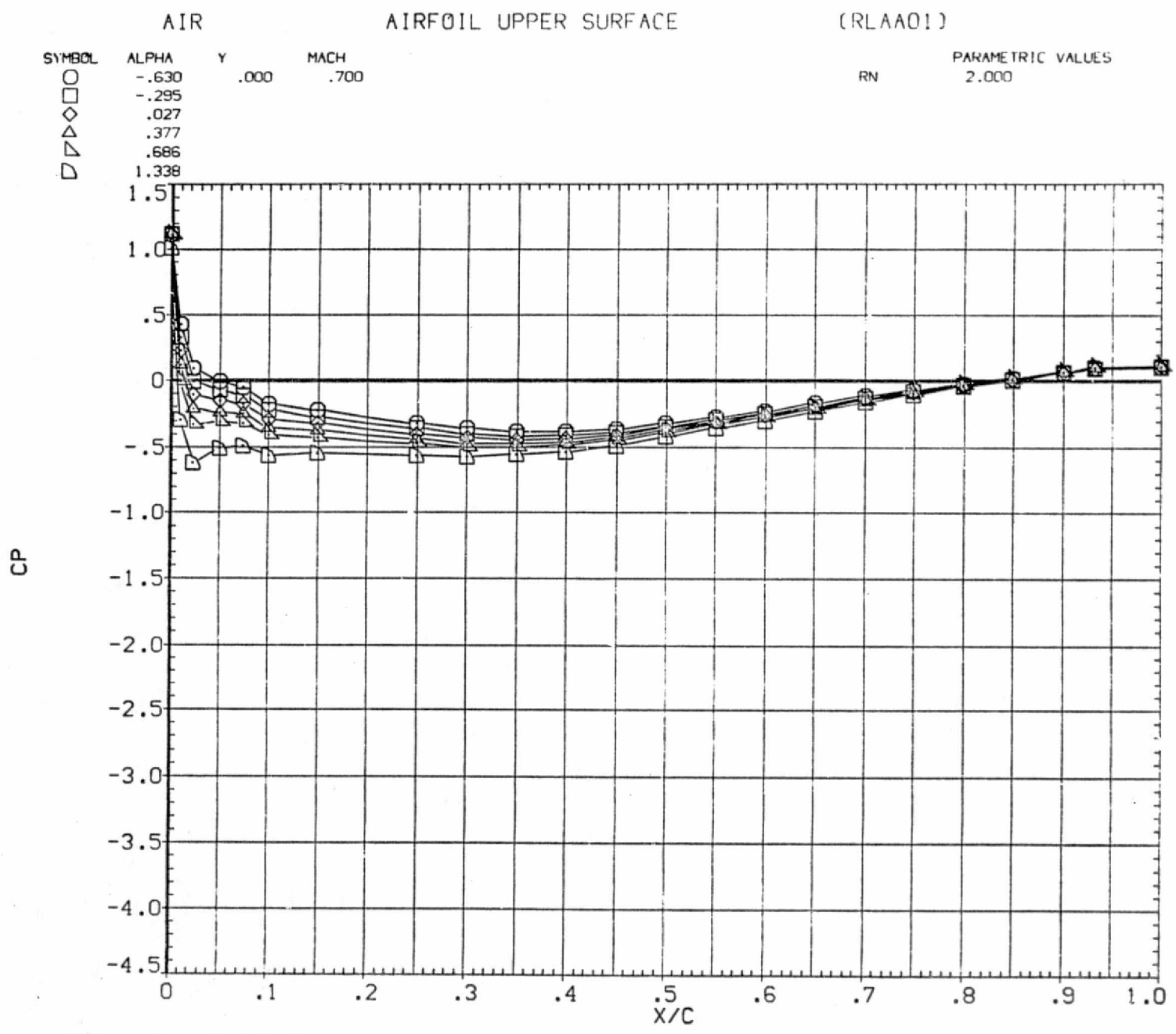

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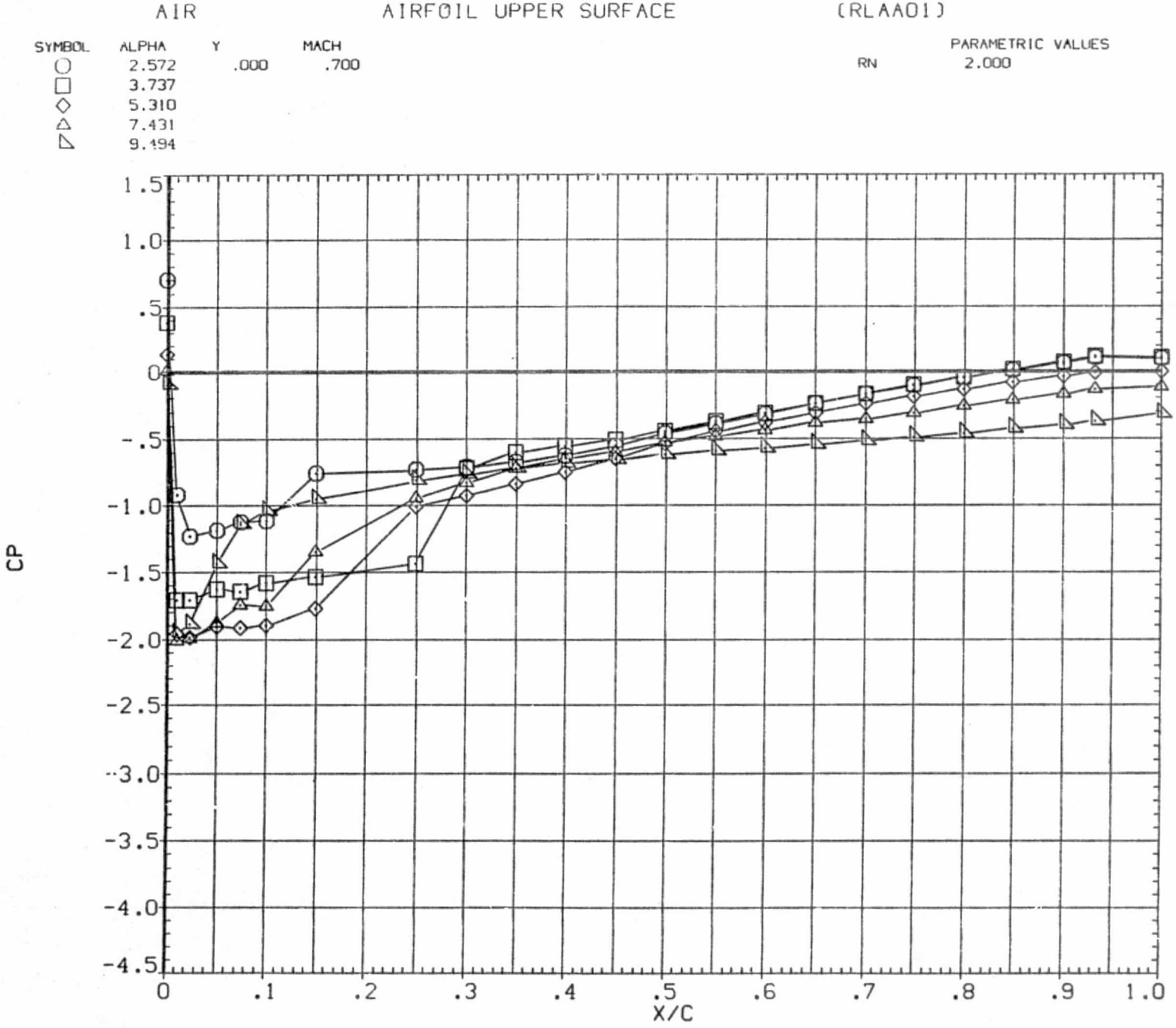

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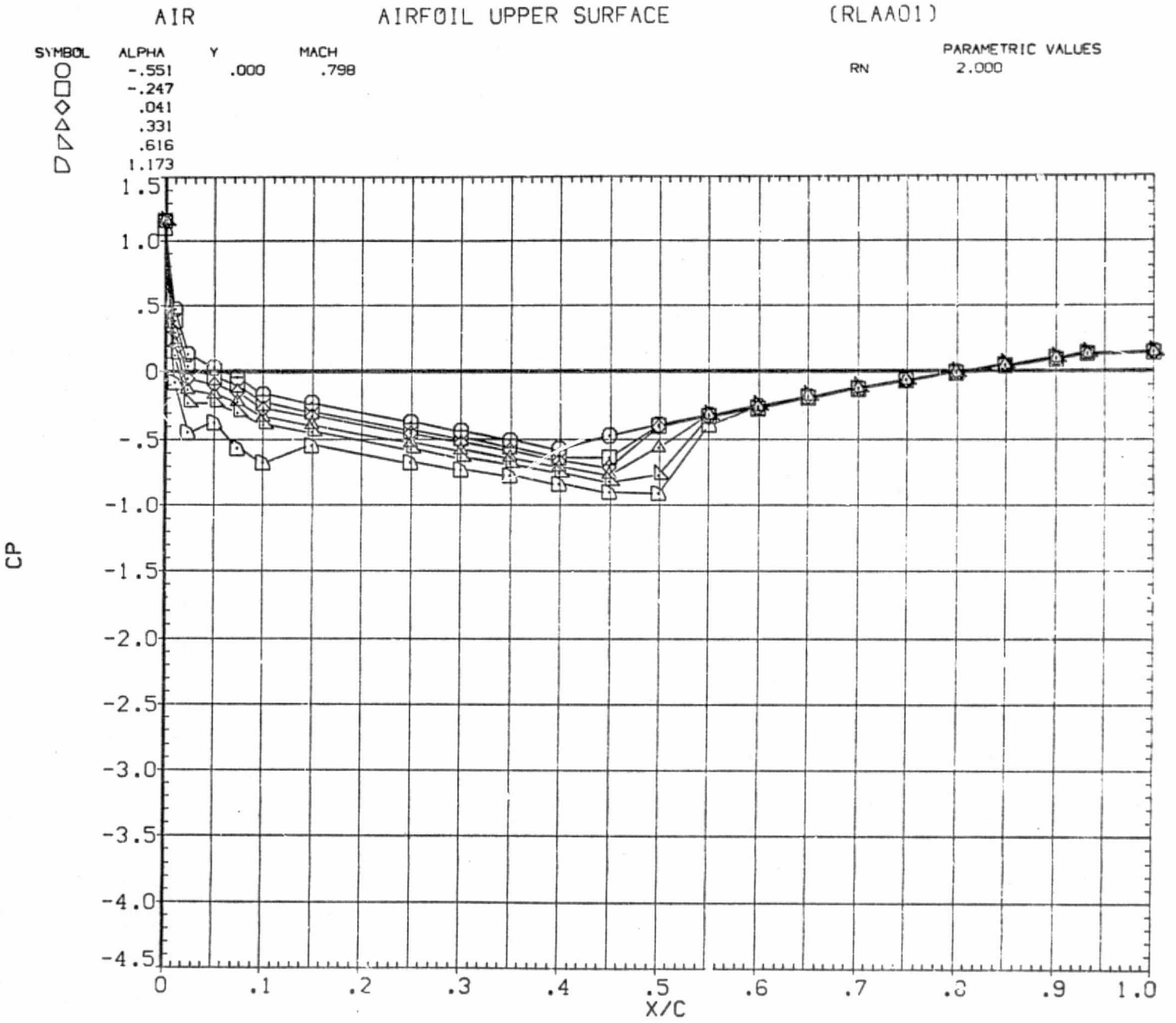


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

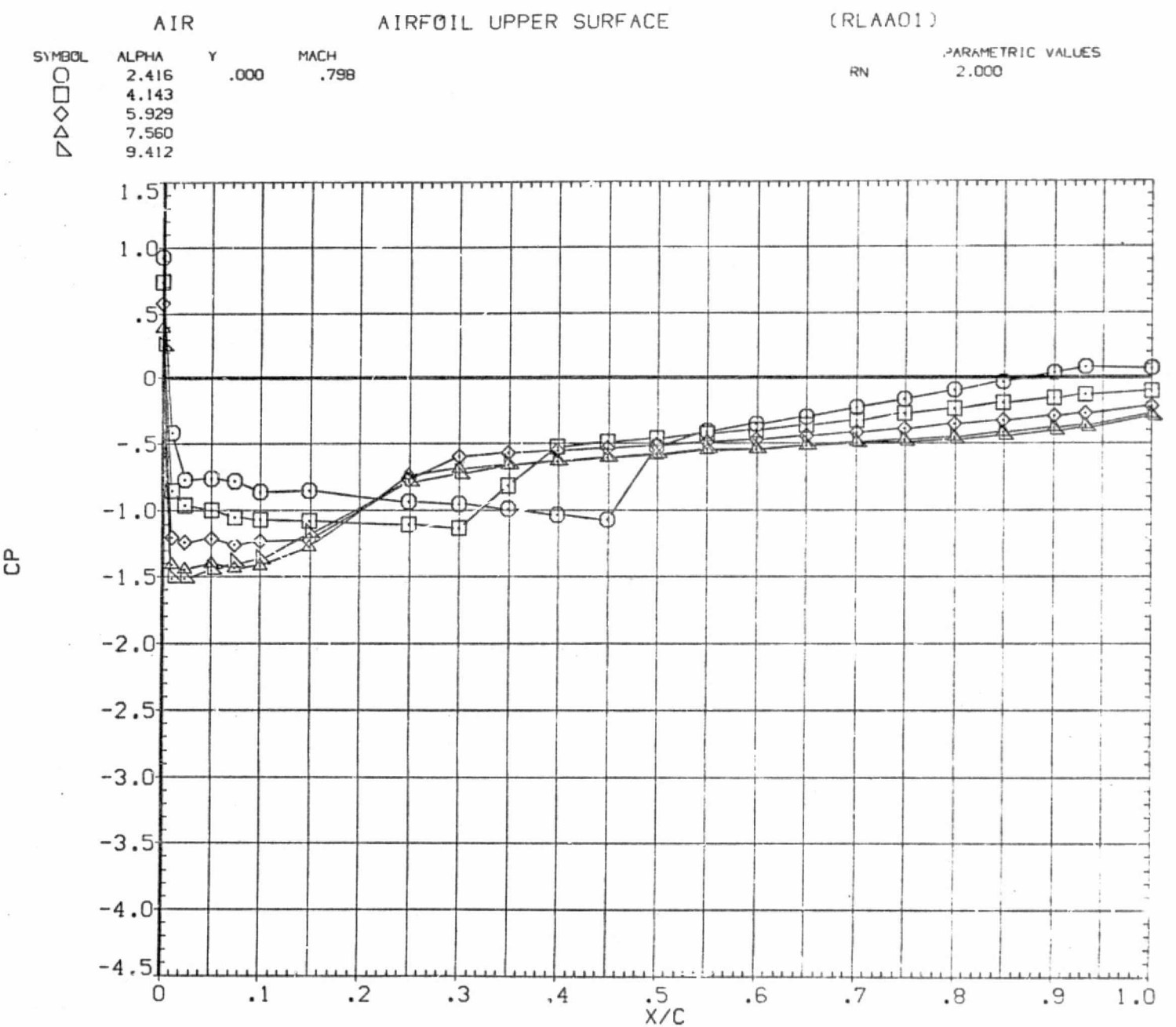


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

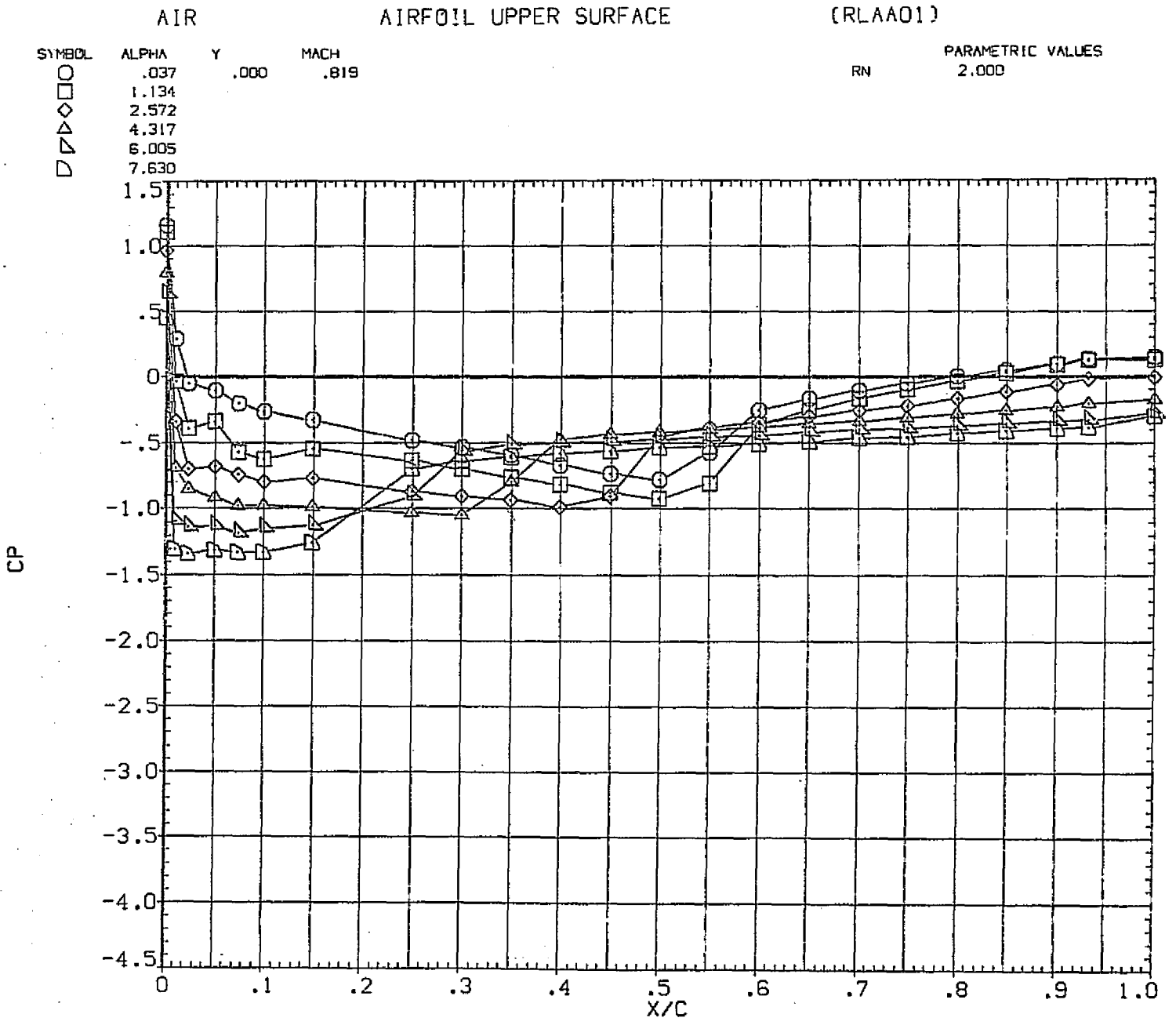


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL UPPER SURFACE (RLAA01)

SYMBOL	ALPHA	Y	MACH
O	9.363	.000	.815

PARAMETRIC VALUES
RN 2.000

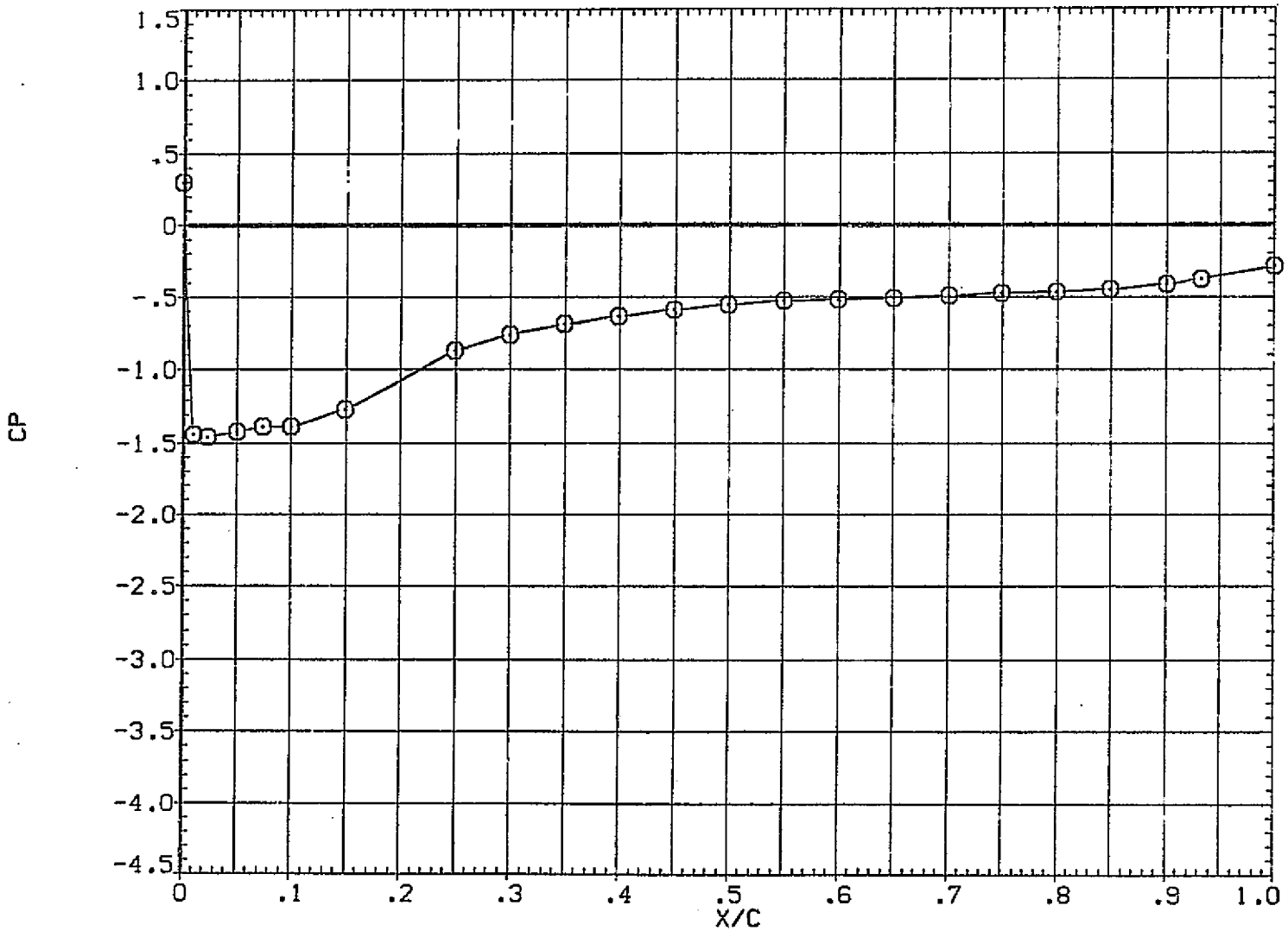


FIG. 3 BASIC CATA, PRESSURE DISTRIBUTIONS IN AIR

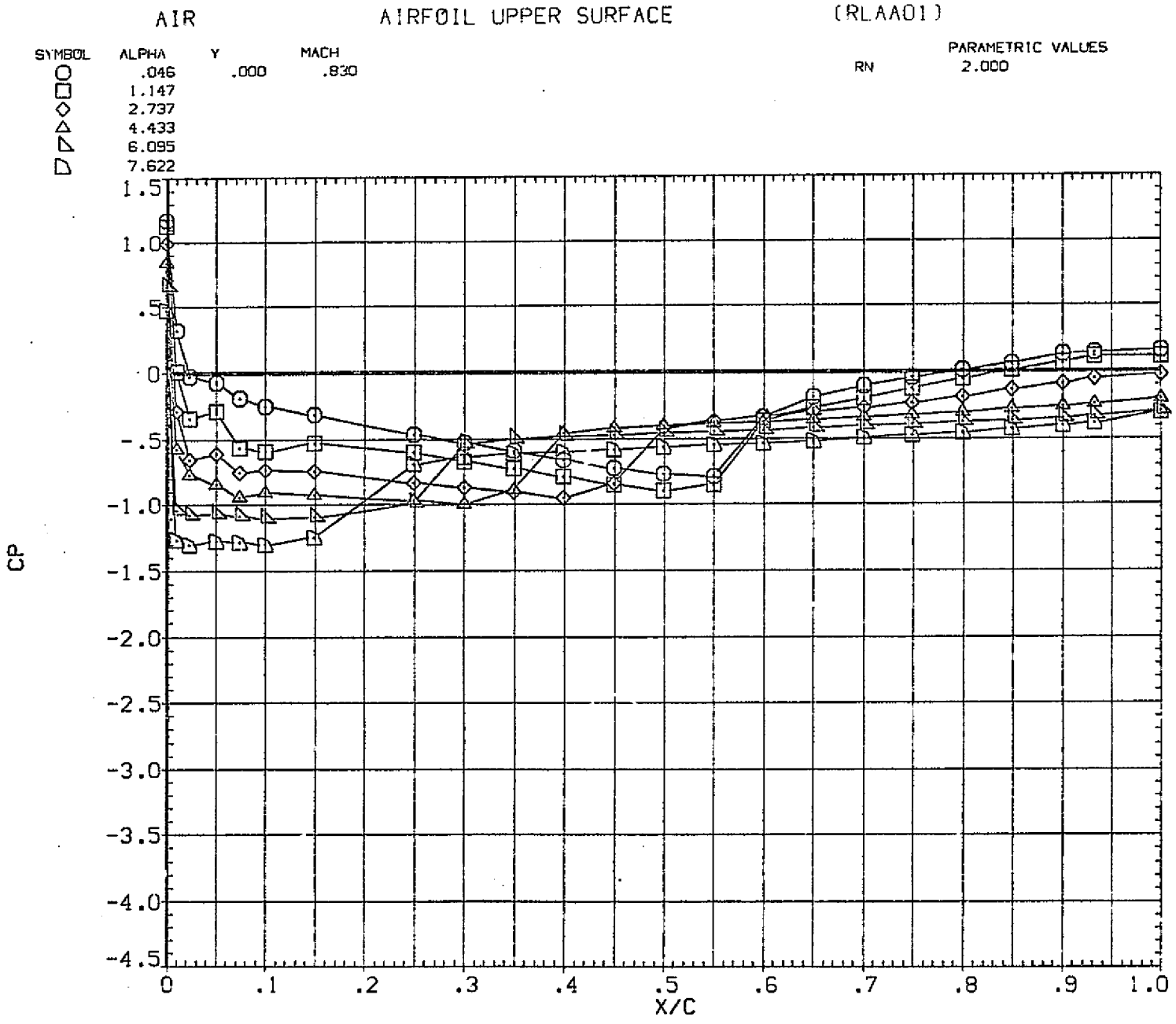


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL UPPER SURFACE (RLAA01)

SYMBOL	ALPHA	Y	MACH	PARAMETRIC VALUES
O	9.281	.000	.830	RN 2.000

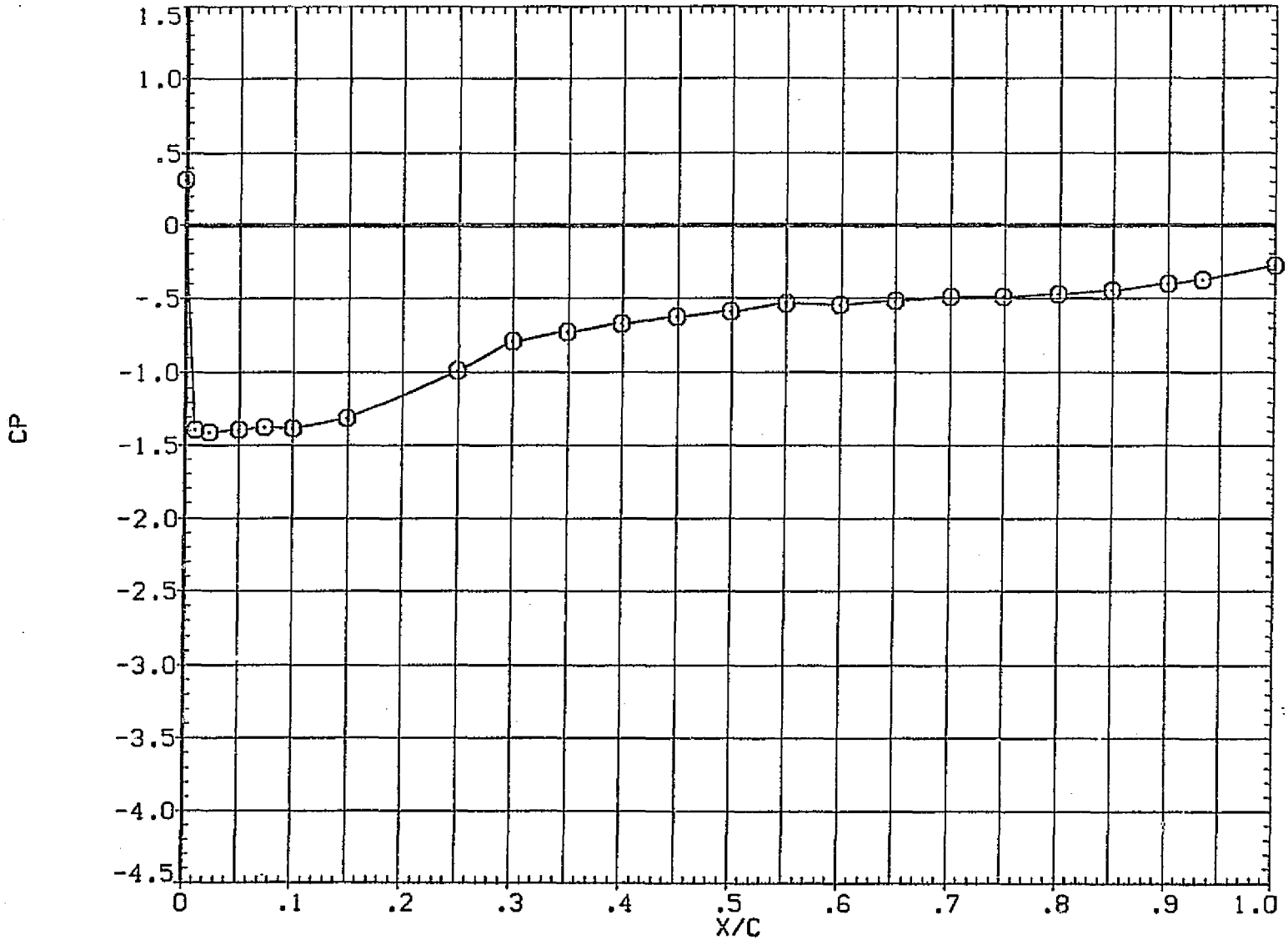


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

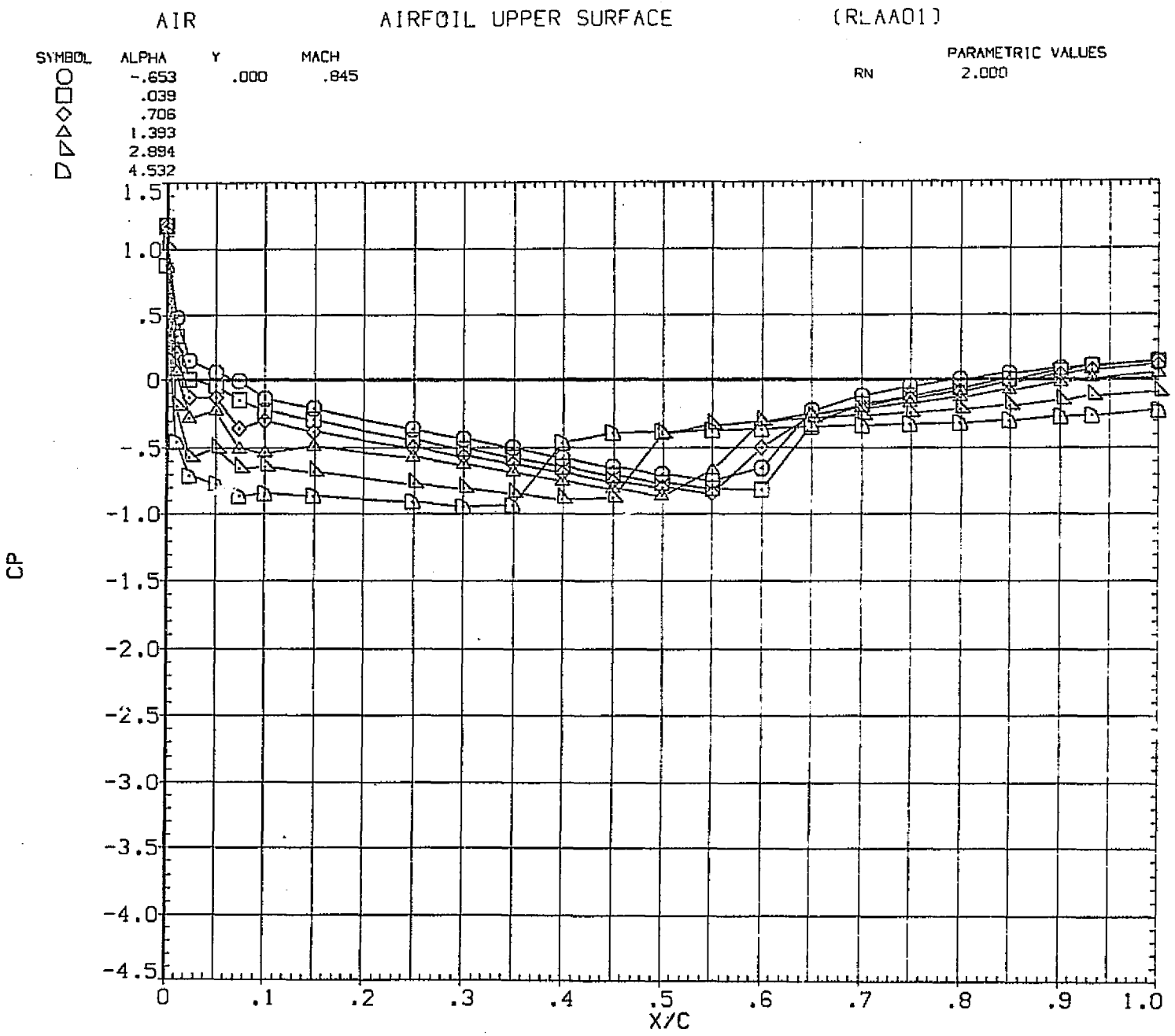


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

SYMBOL	ALPHA	Y	MACH
○	6.149	.000	.845
□	7.758		
◇	9.163		

PARAMETRIC VALUES
RN 1.000

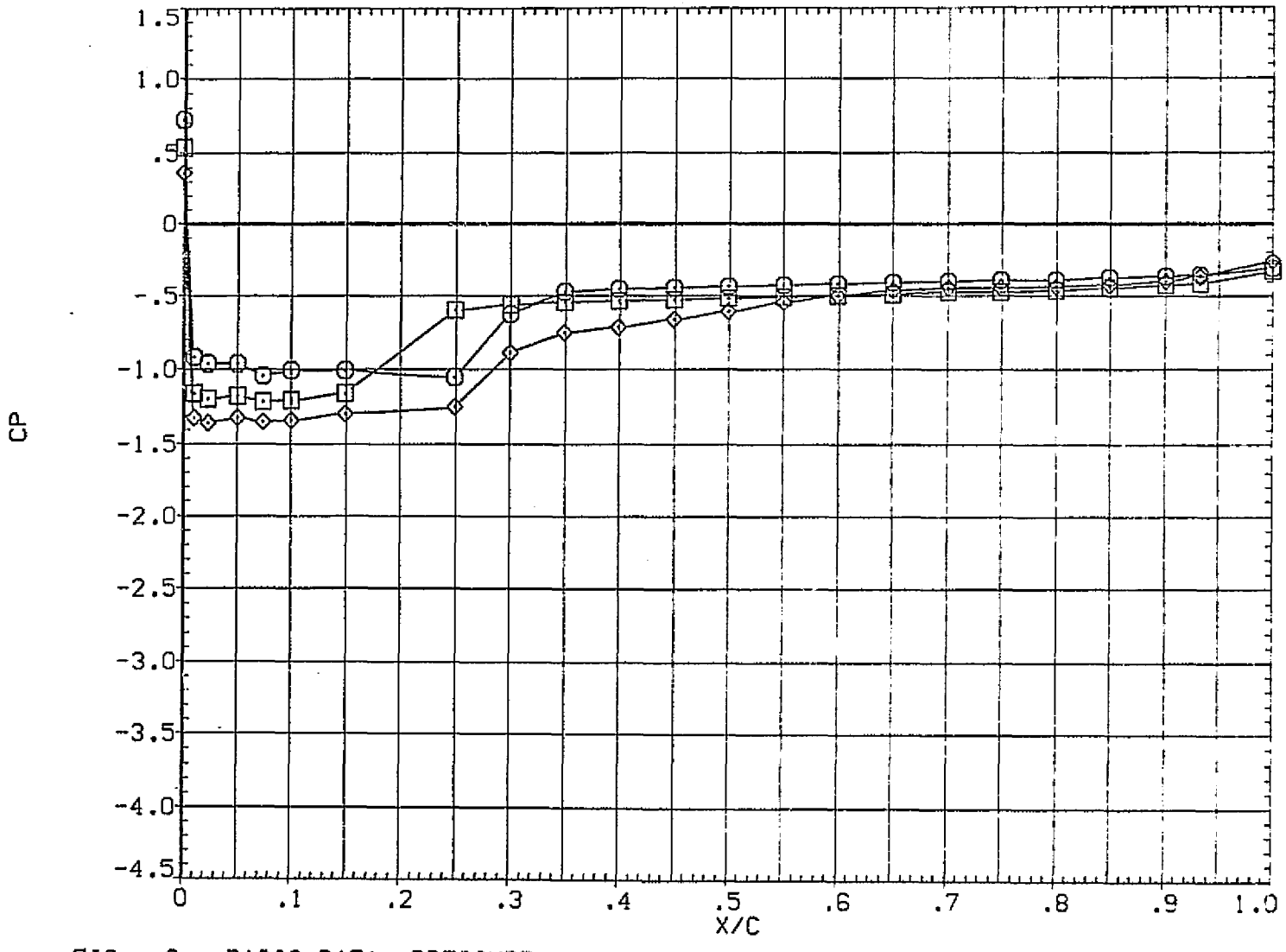


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

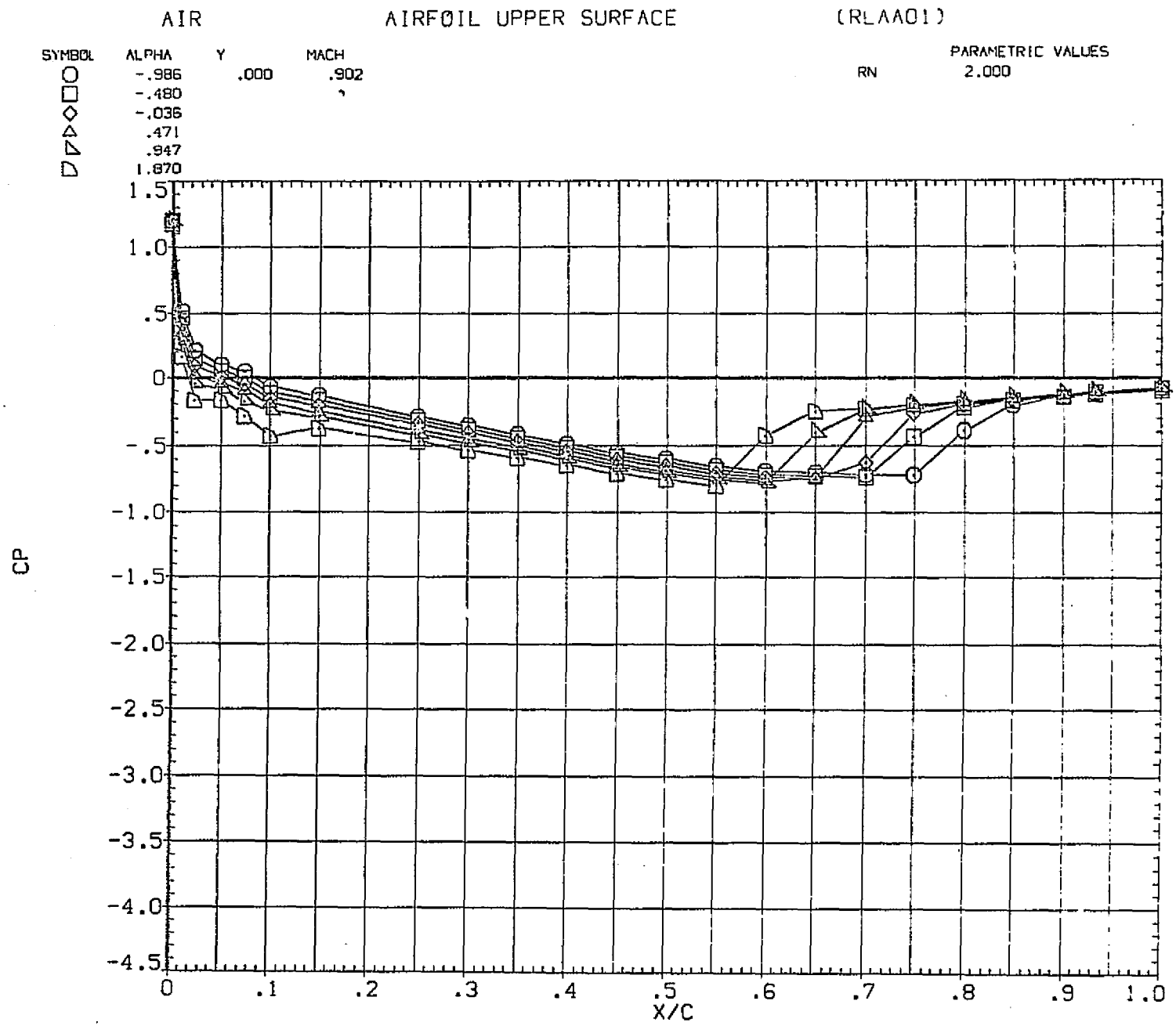


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL UPPER SURFACE (RLAA01)

SYMBOL	ALPHA	Y	MACH
○	3.470	.000	.902
□	4.939		
◇	6.119		
△	7.601		

PARAMETRIC VALUES
RN 2.000

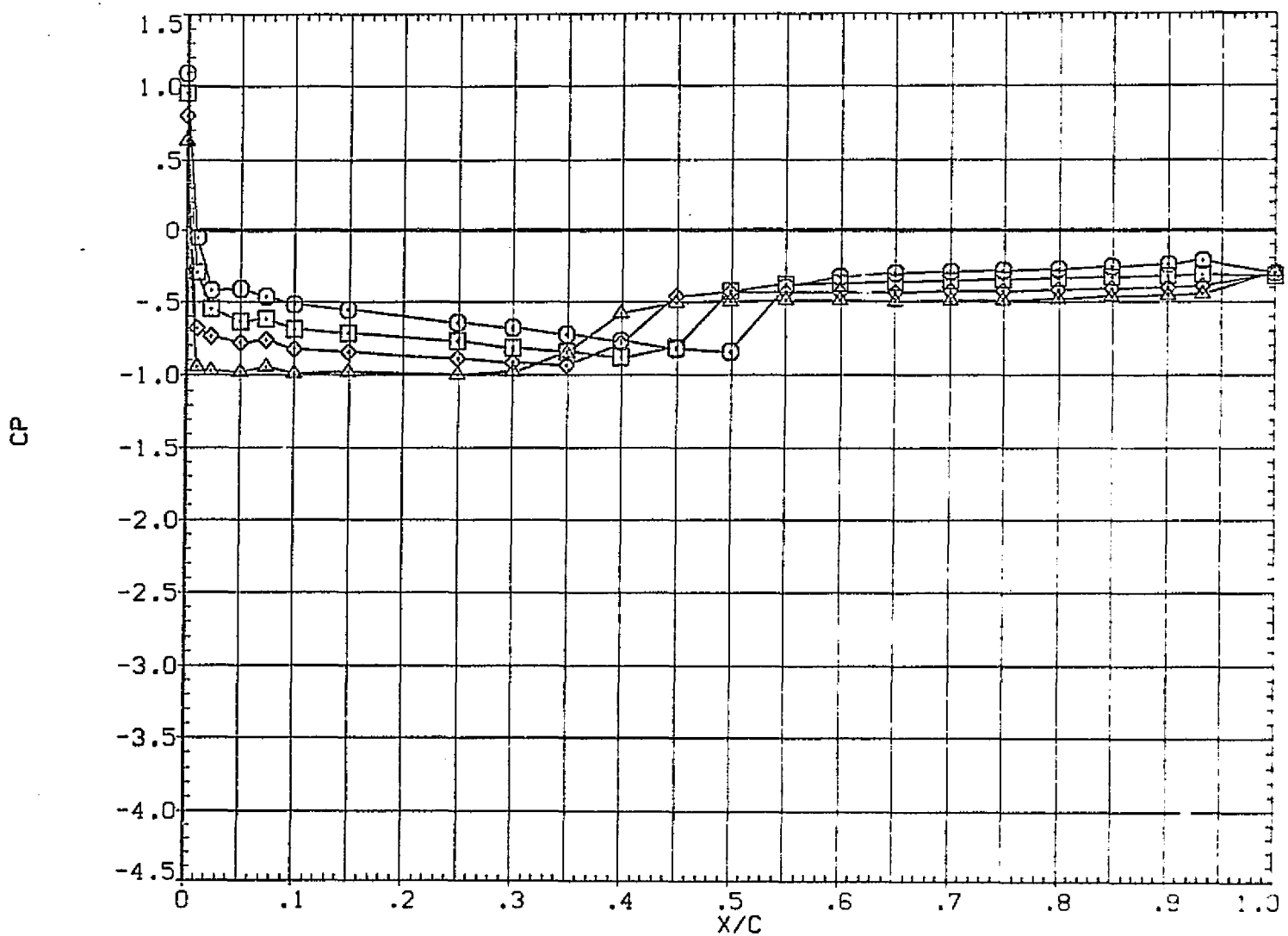


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

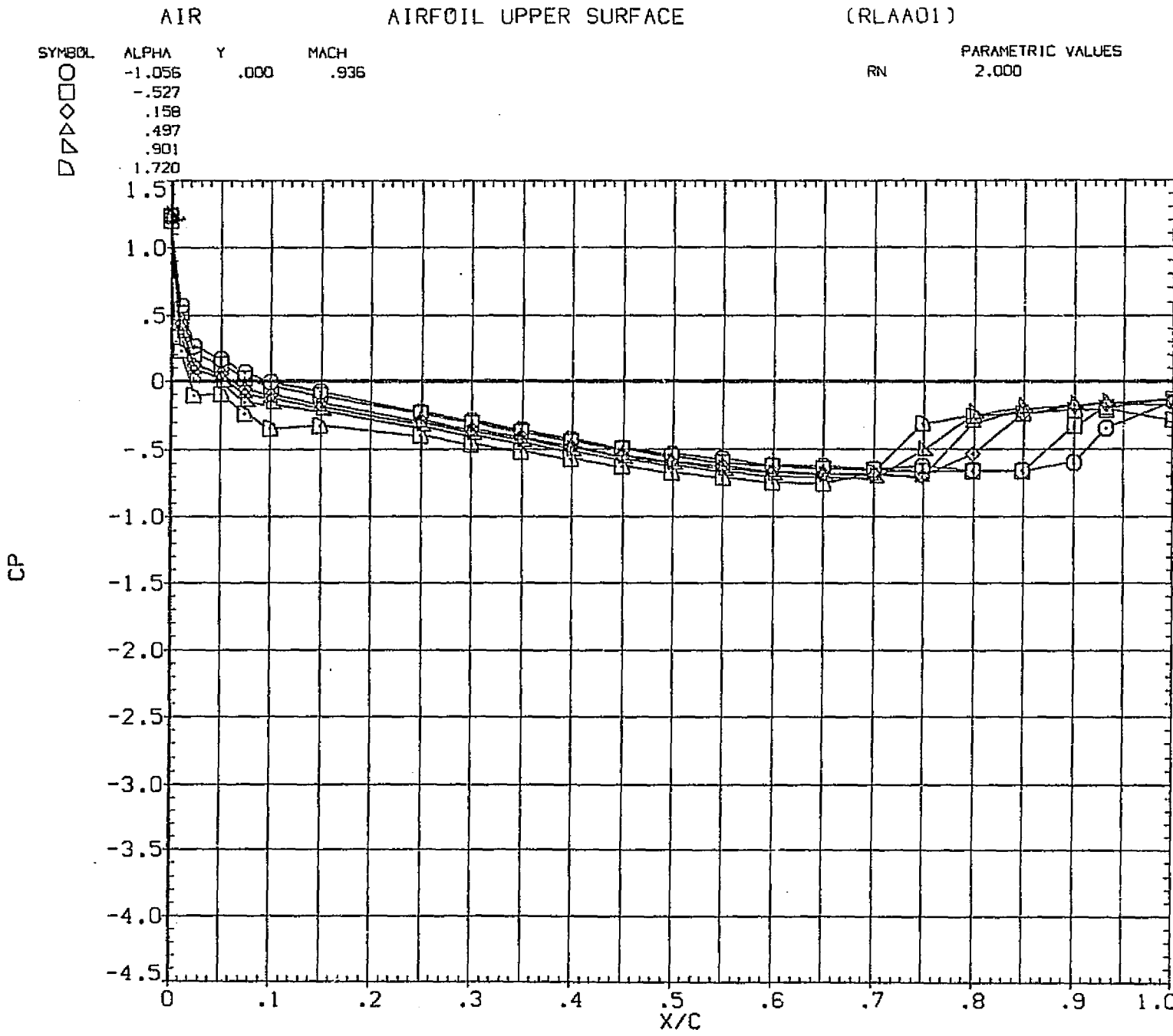


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

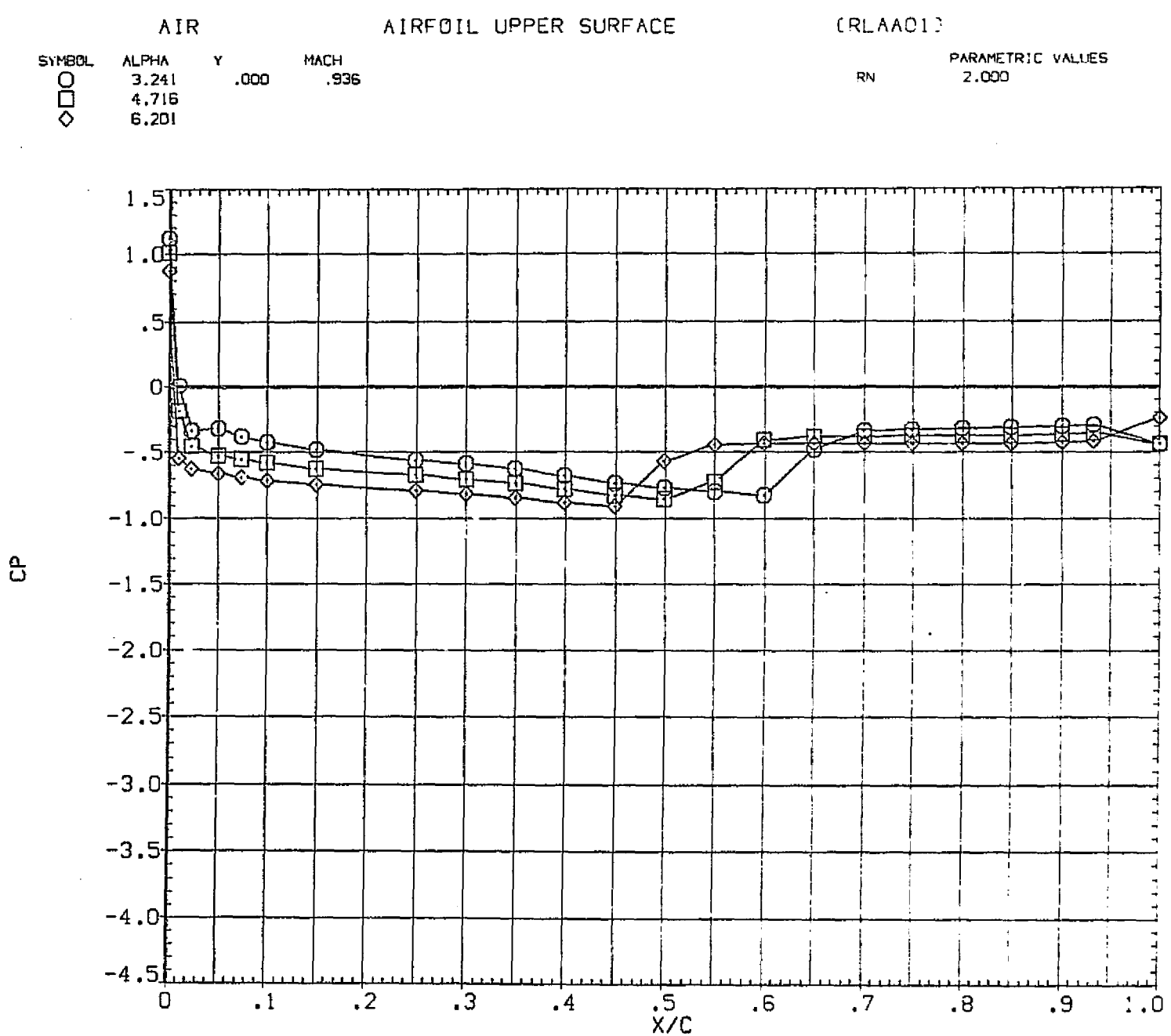


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

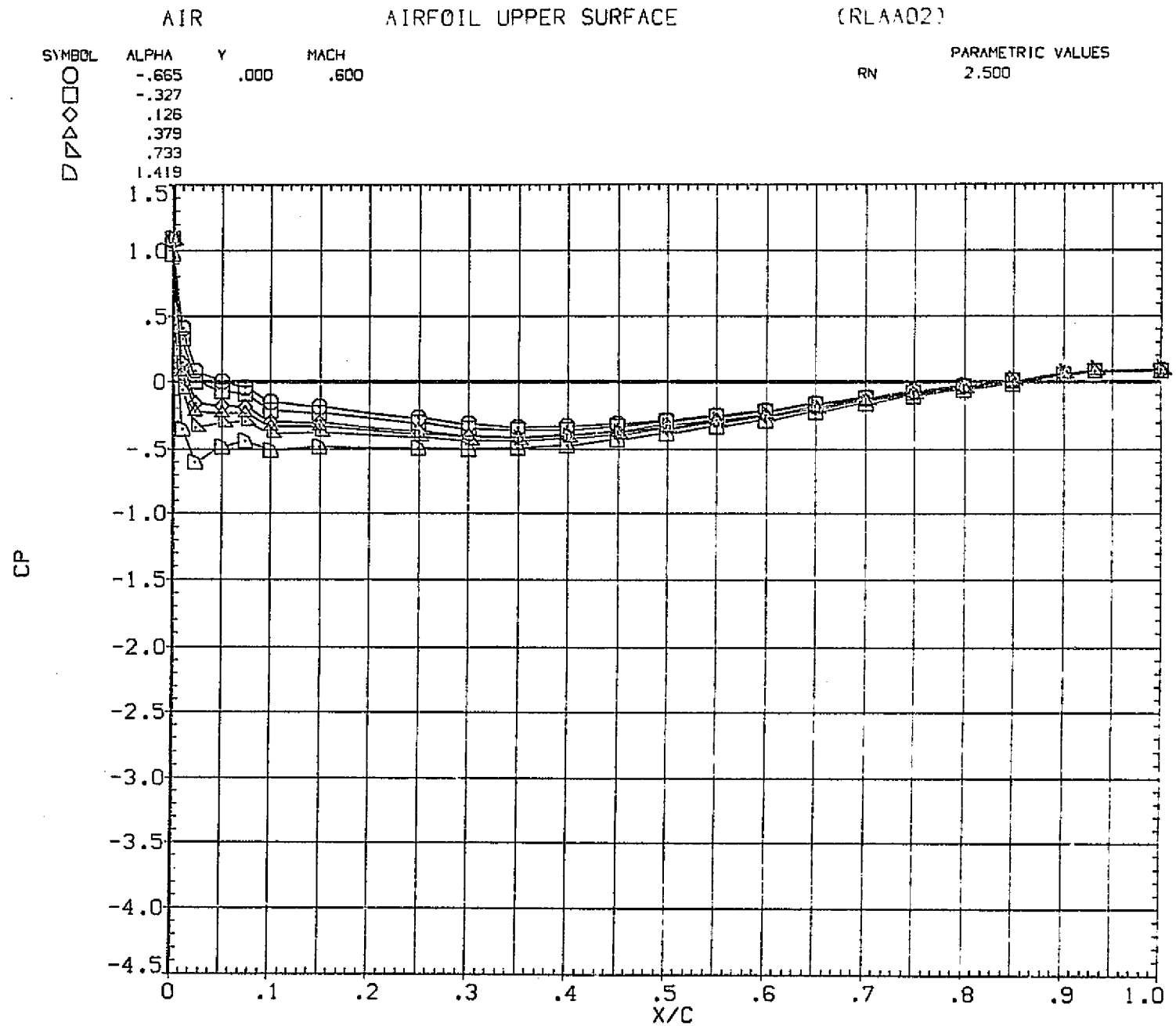


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

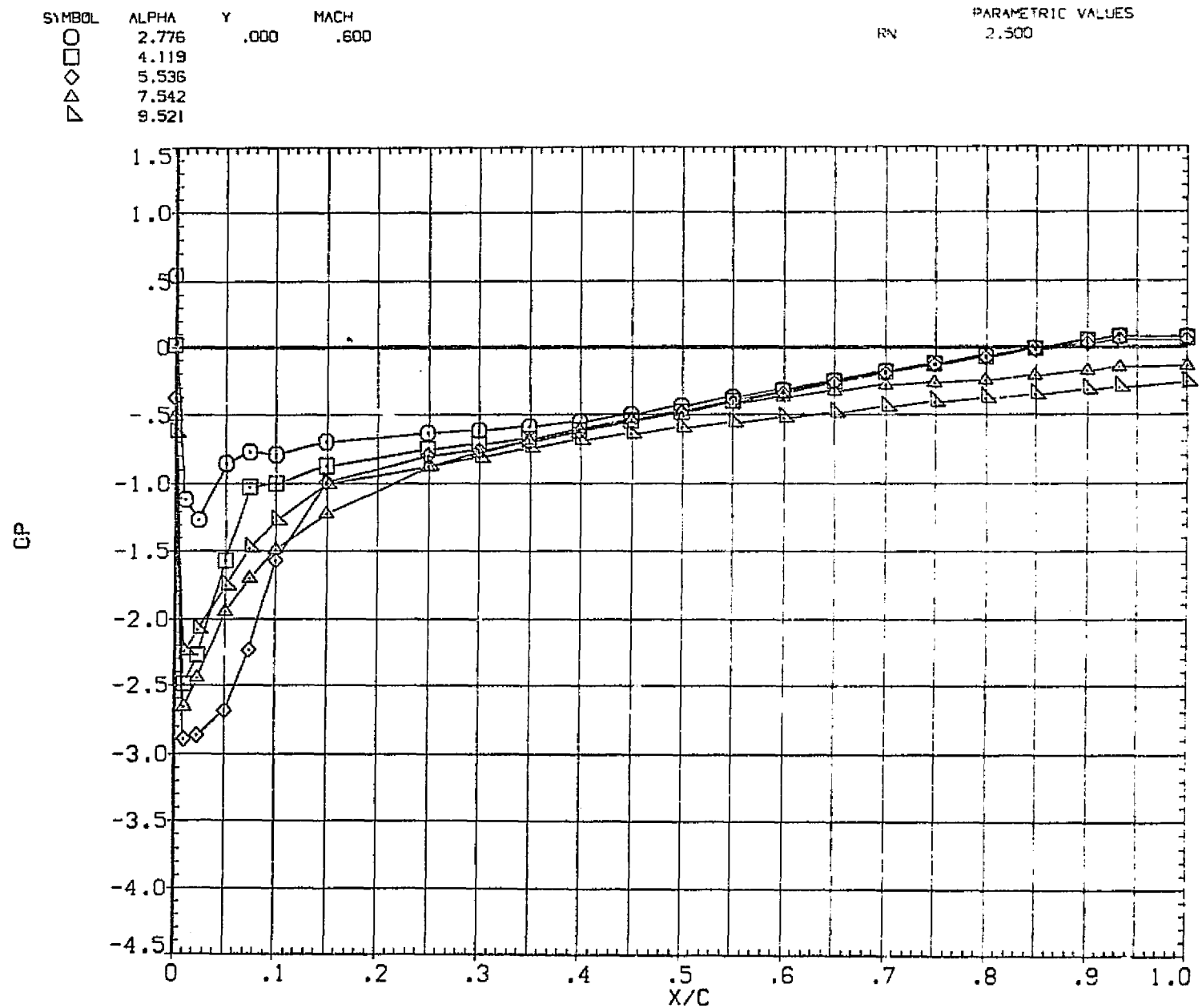


FIG. 9 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

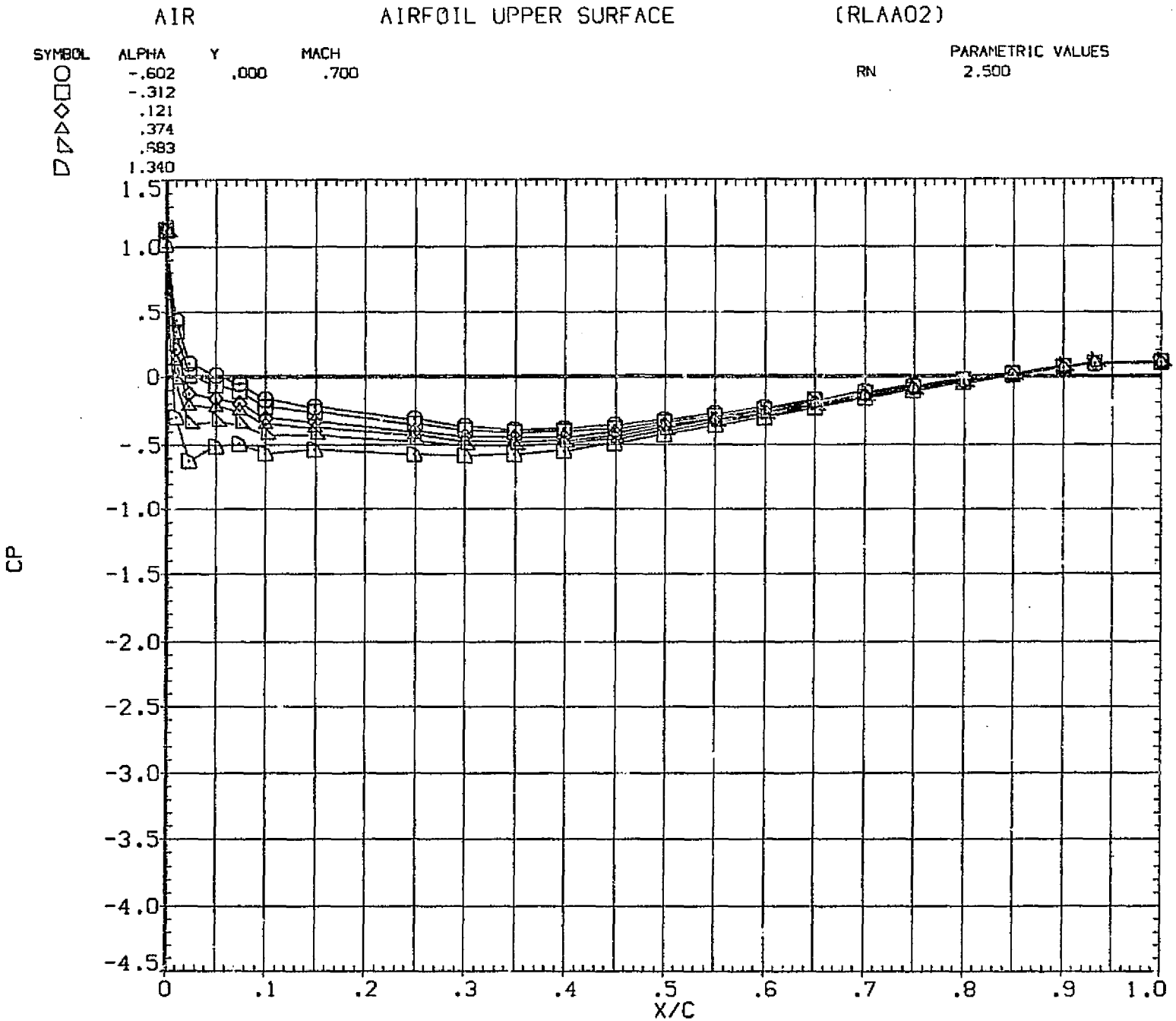


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

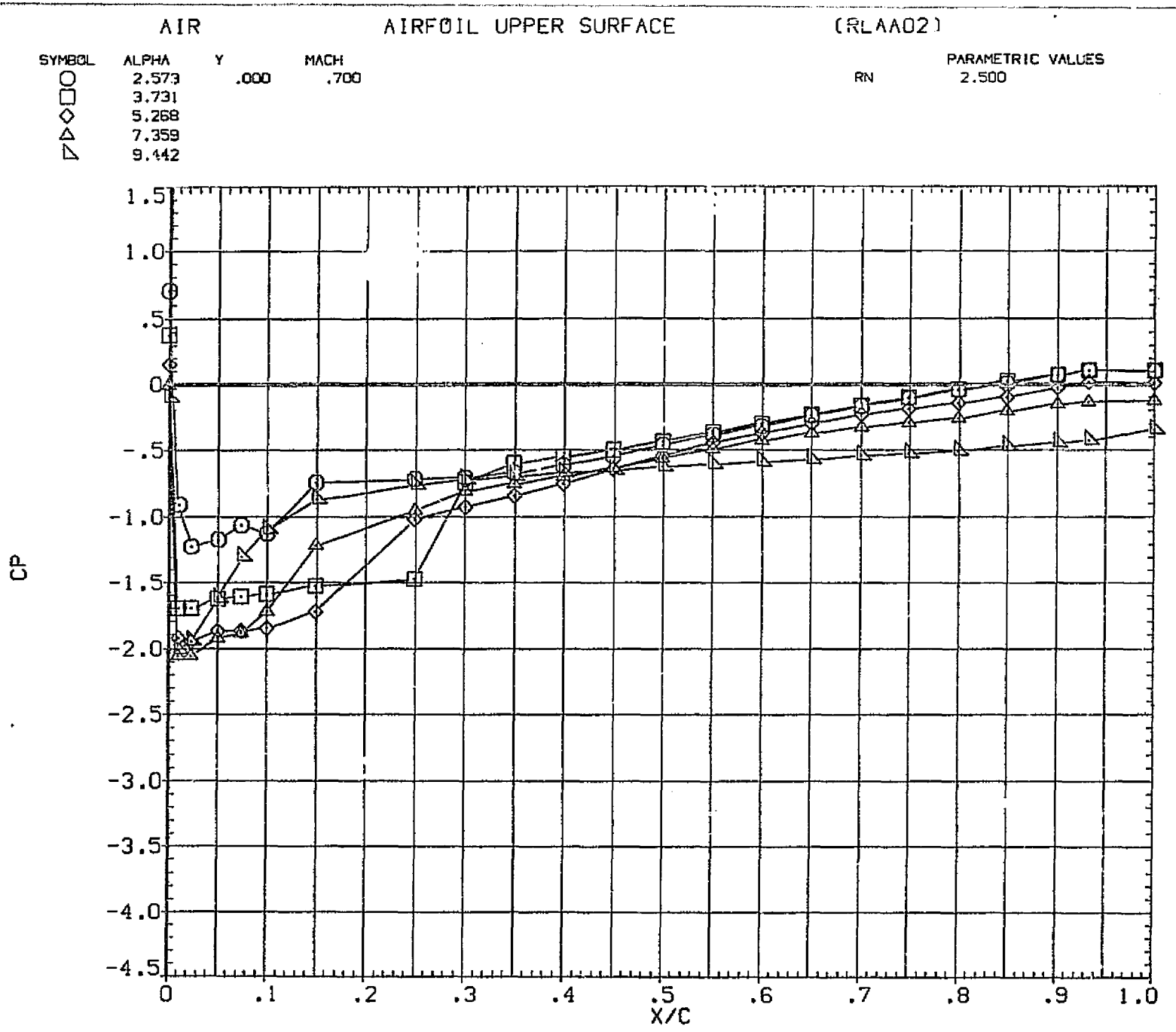


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

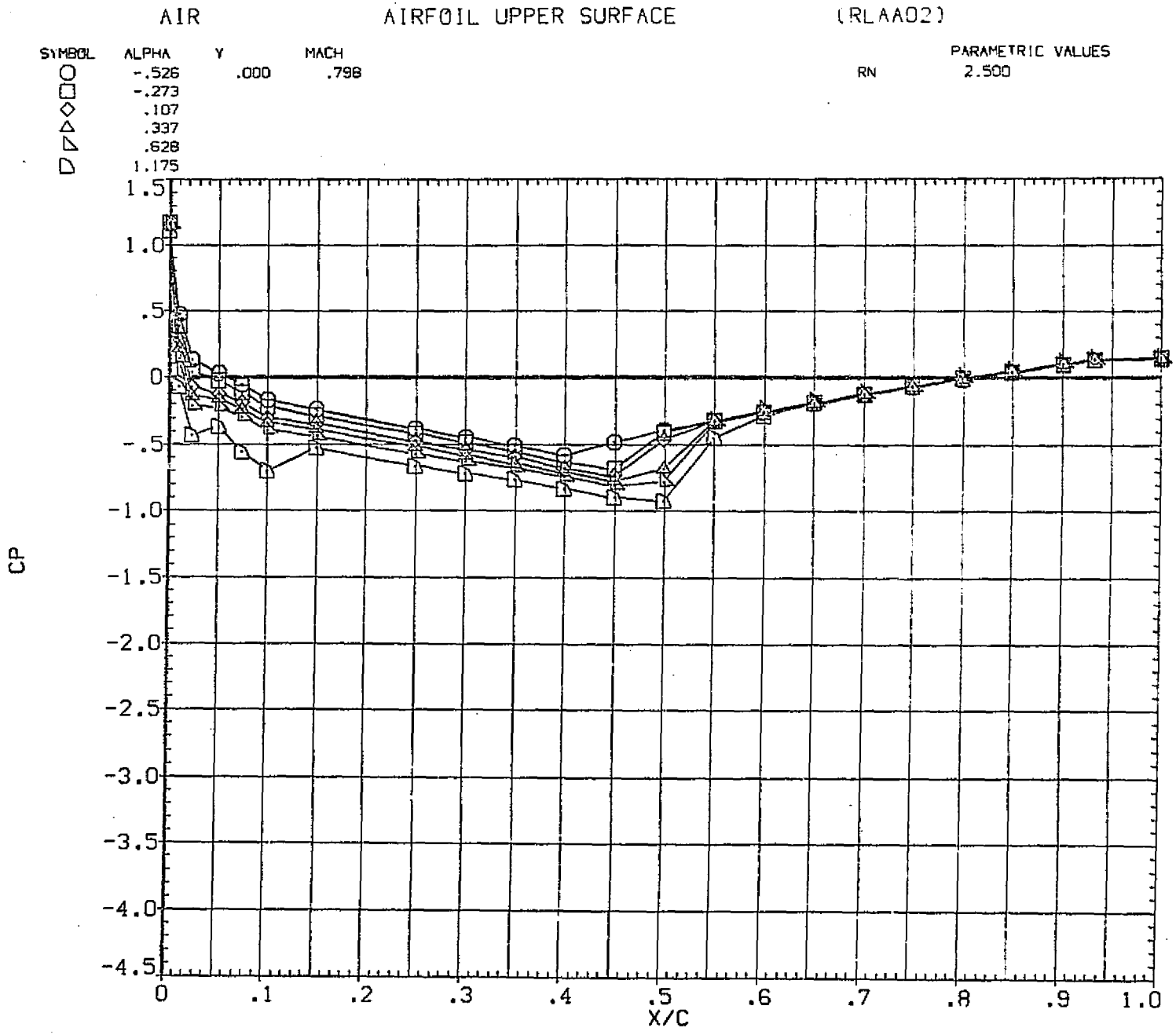


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

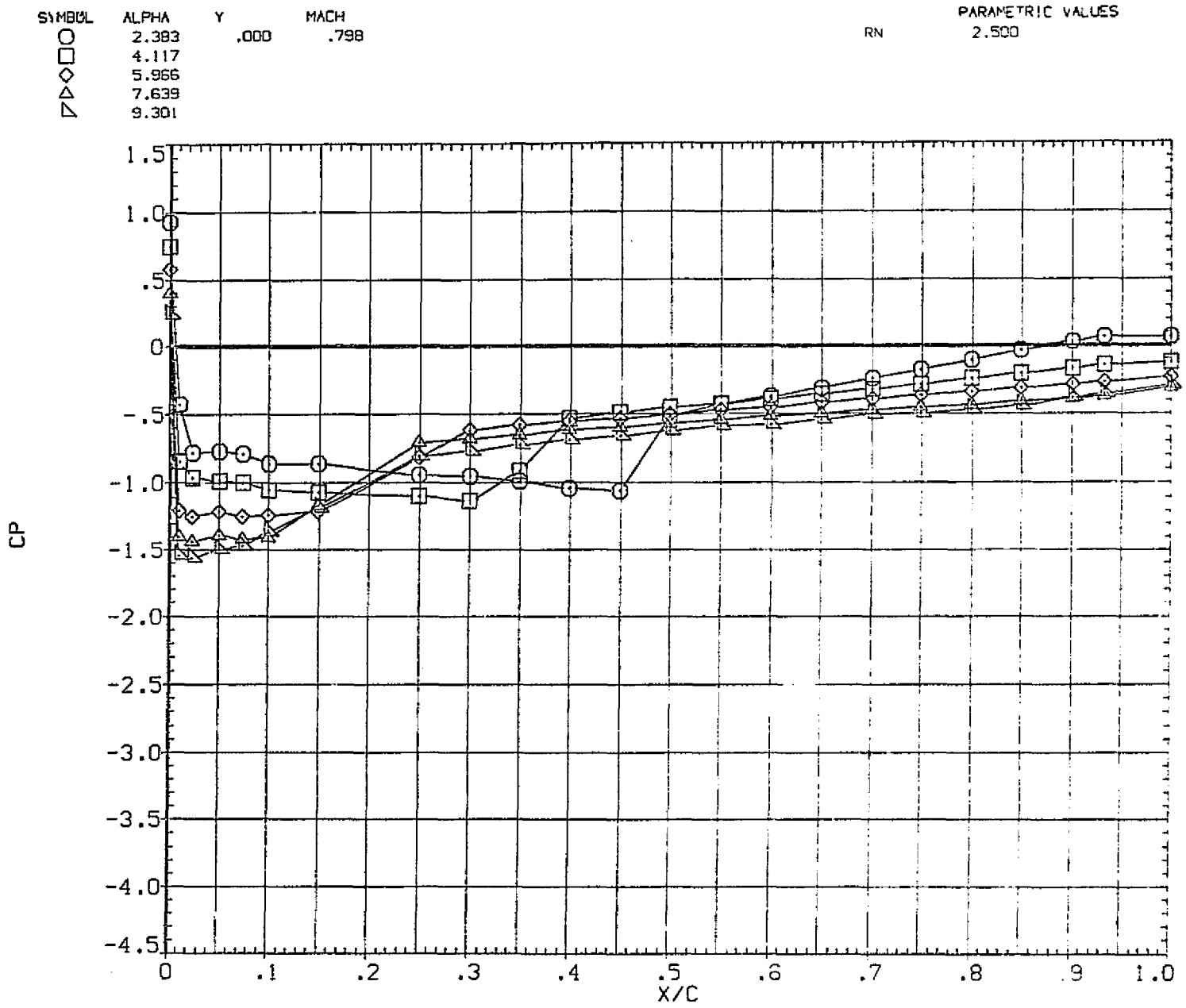


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

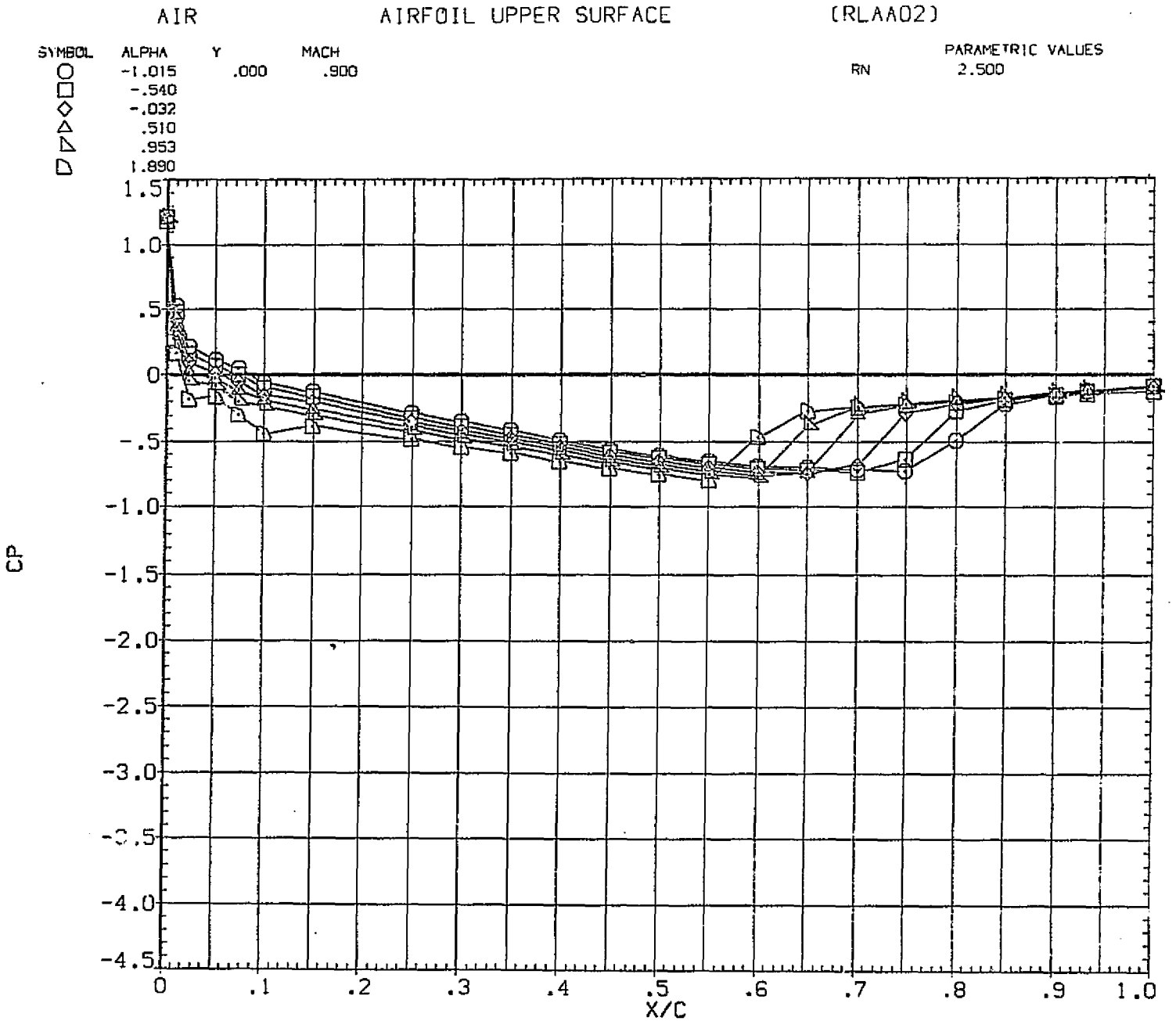


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

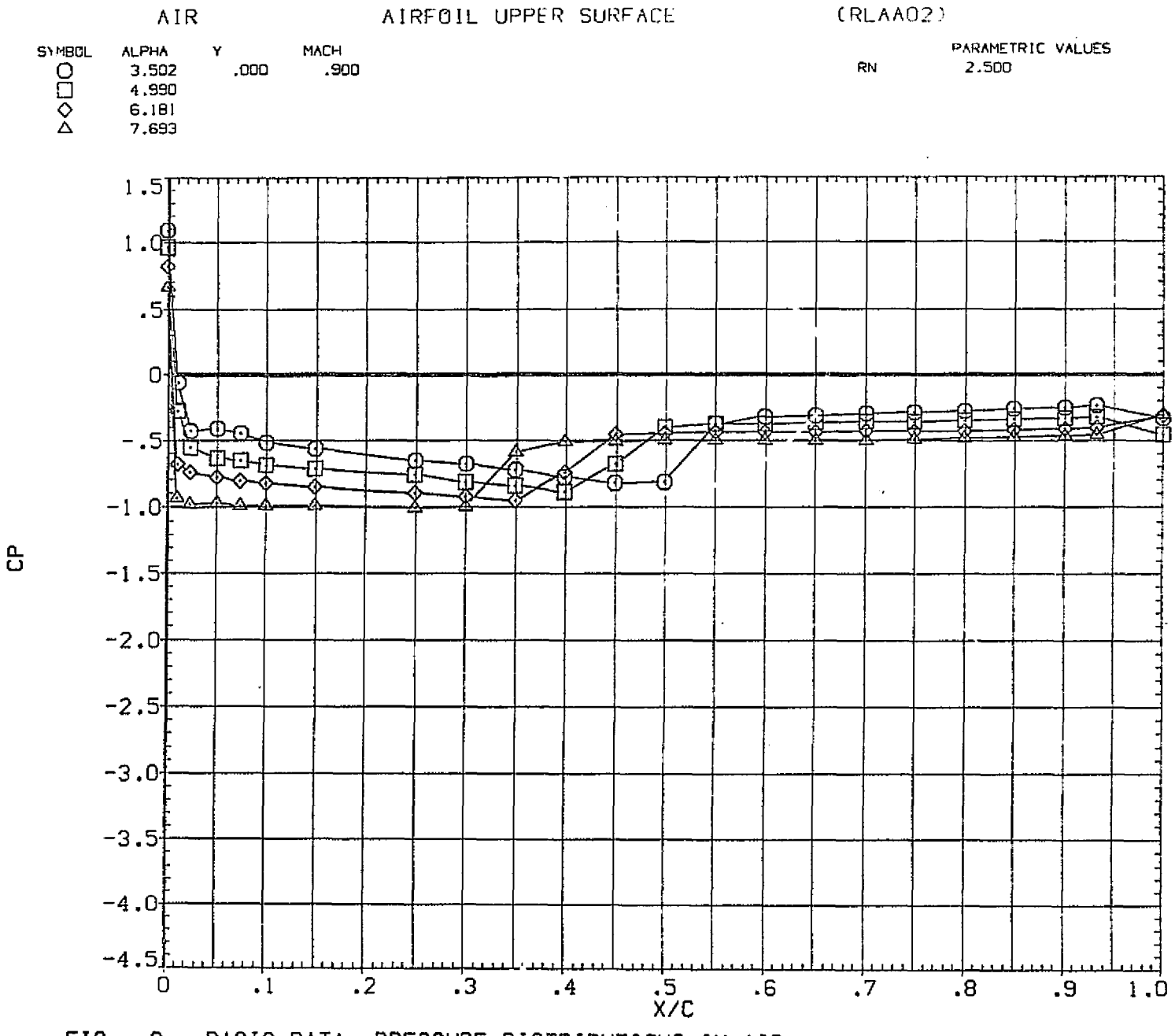


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

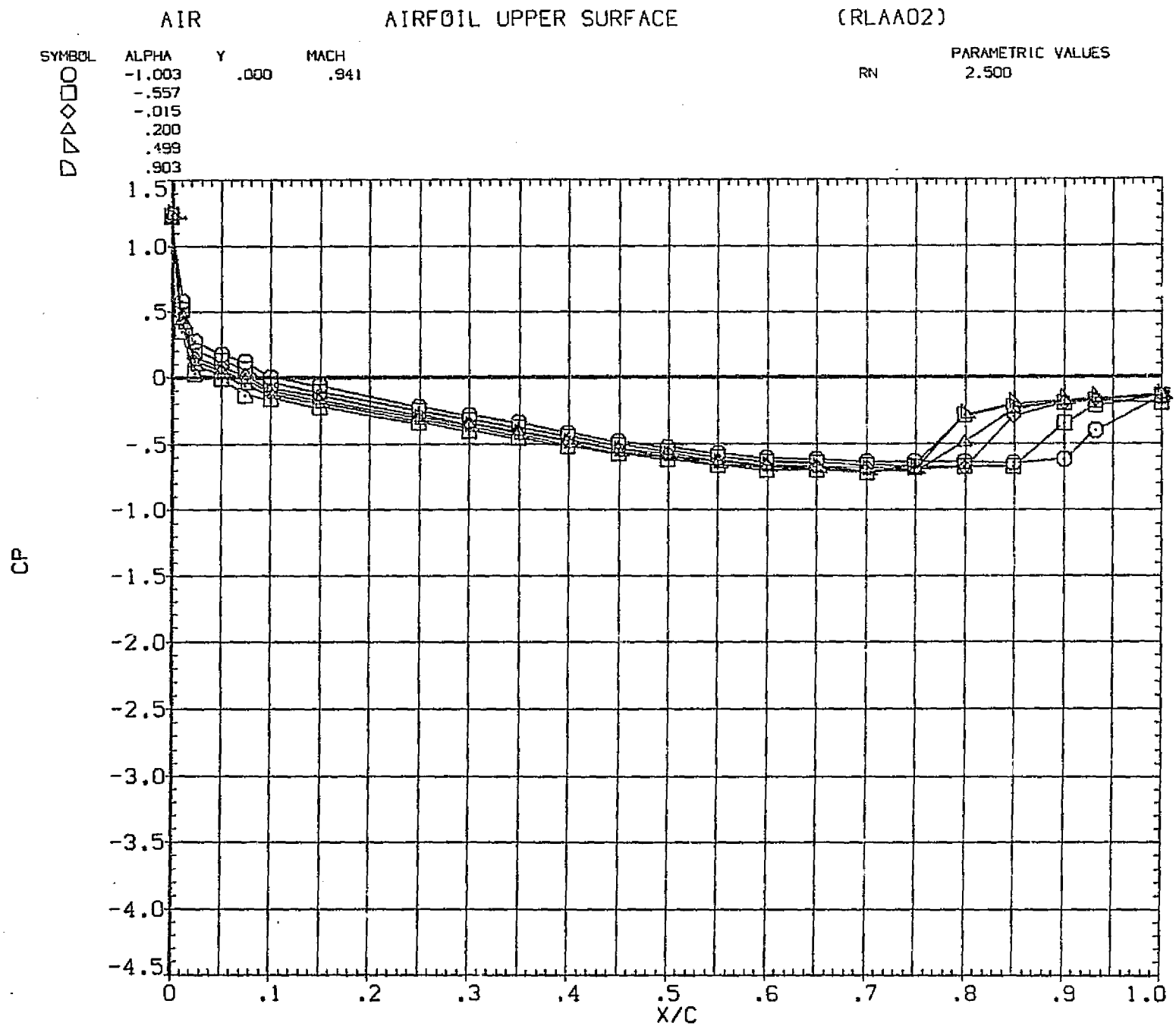


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

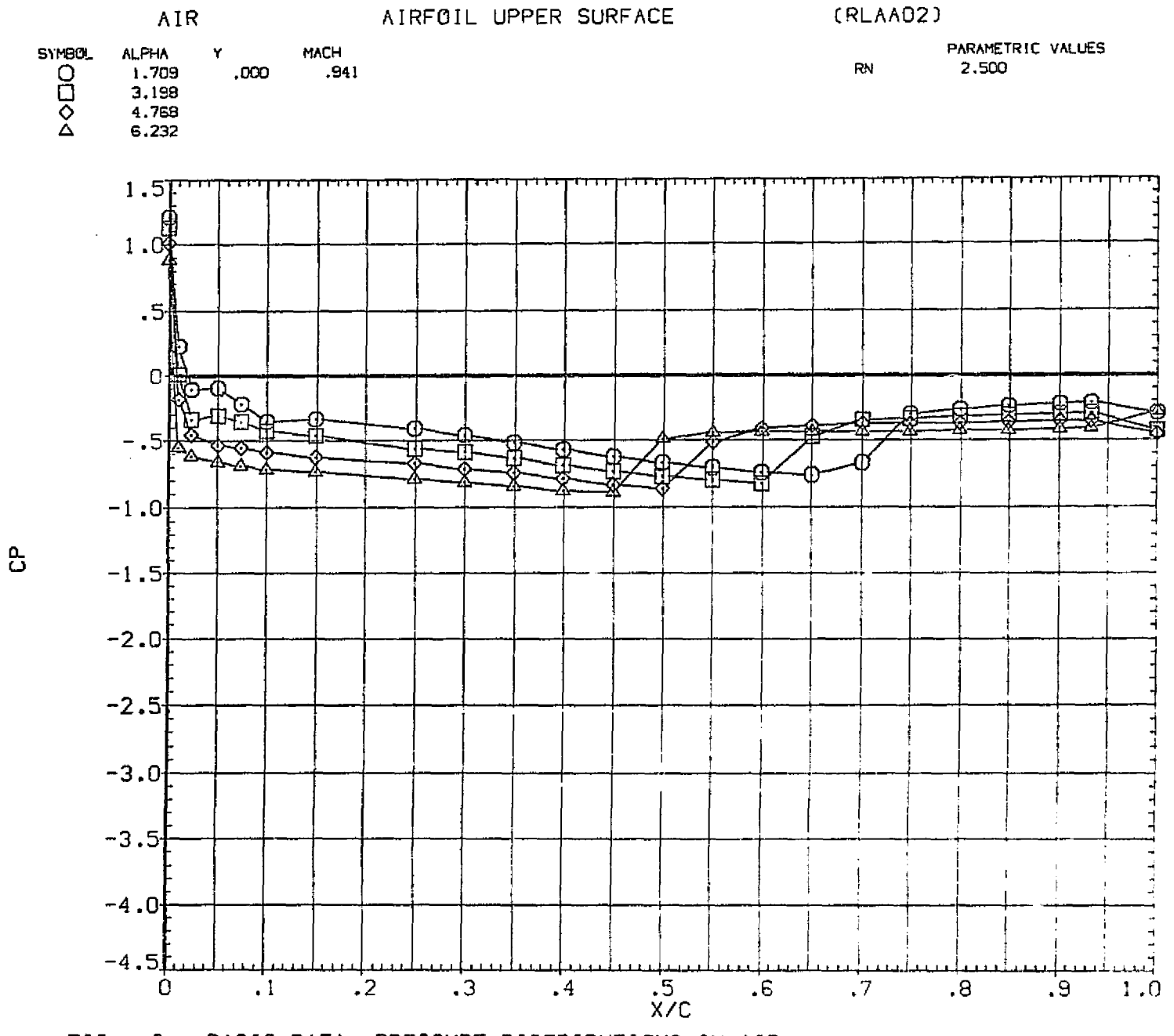


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

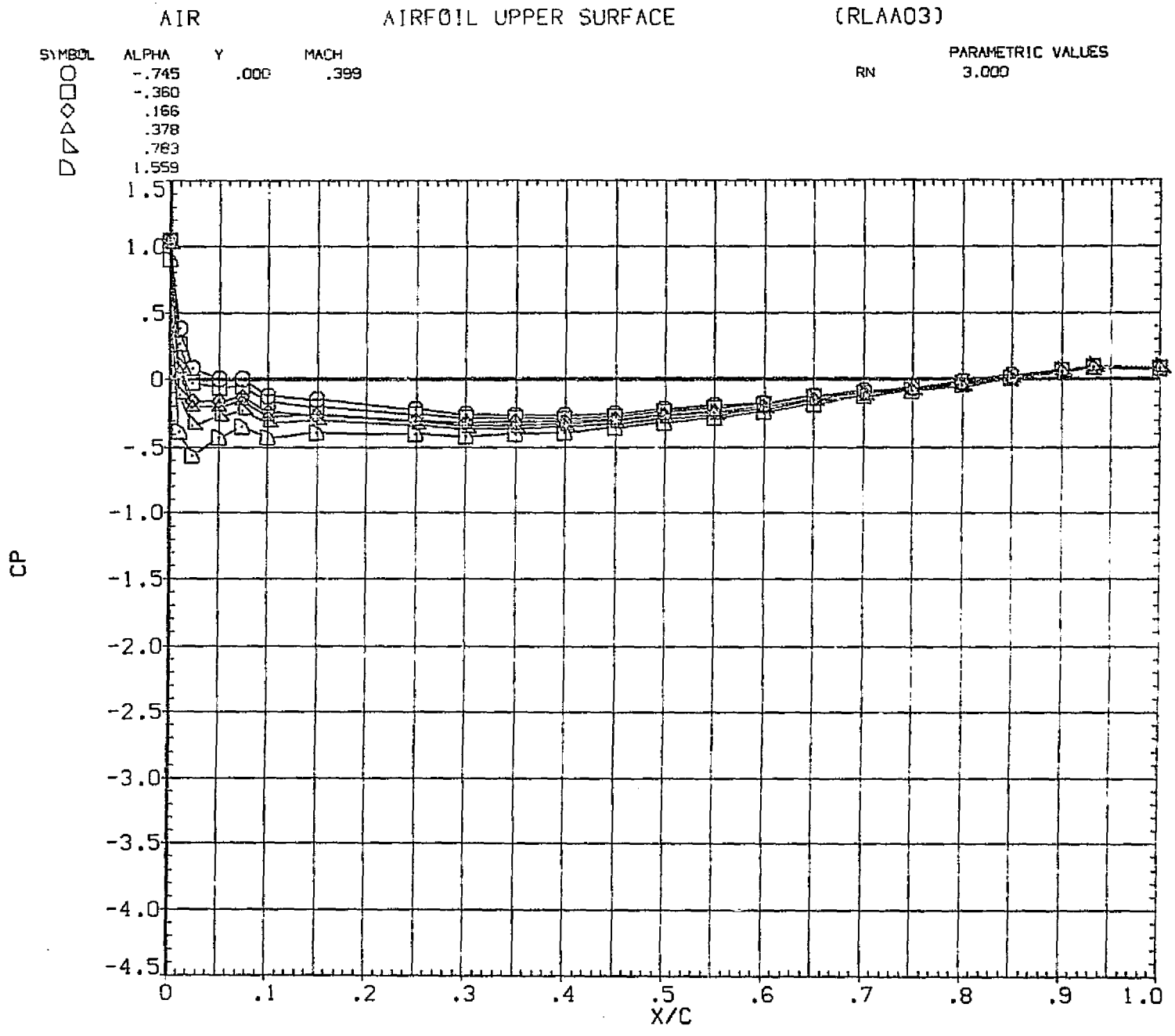


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

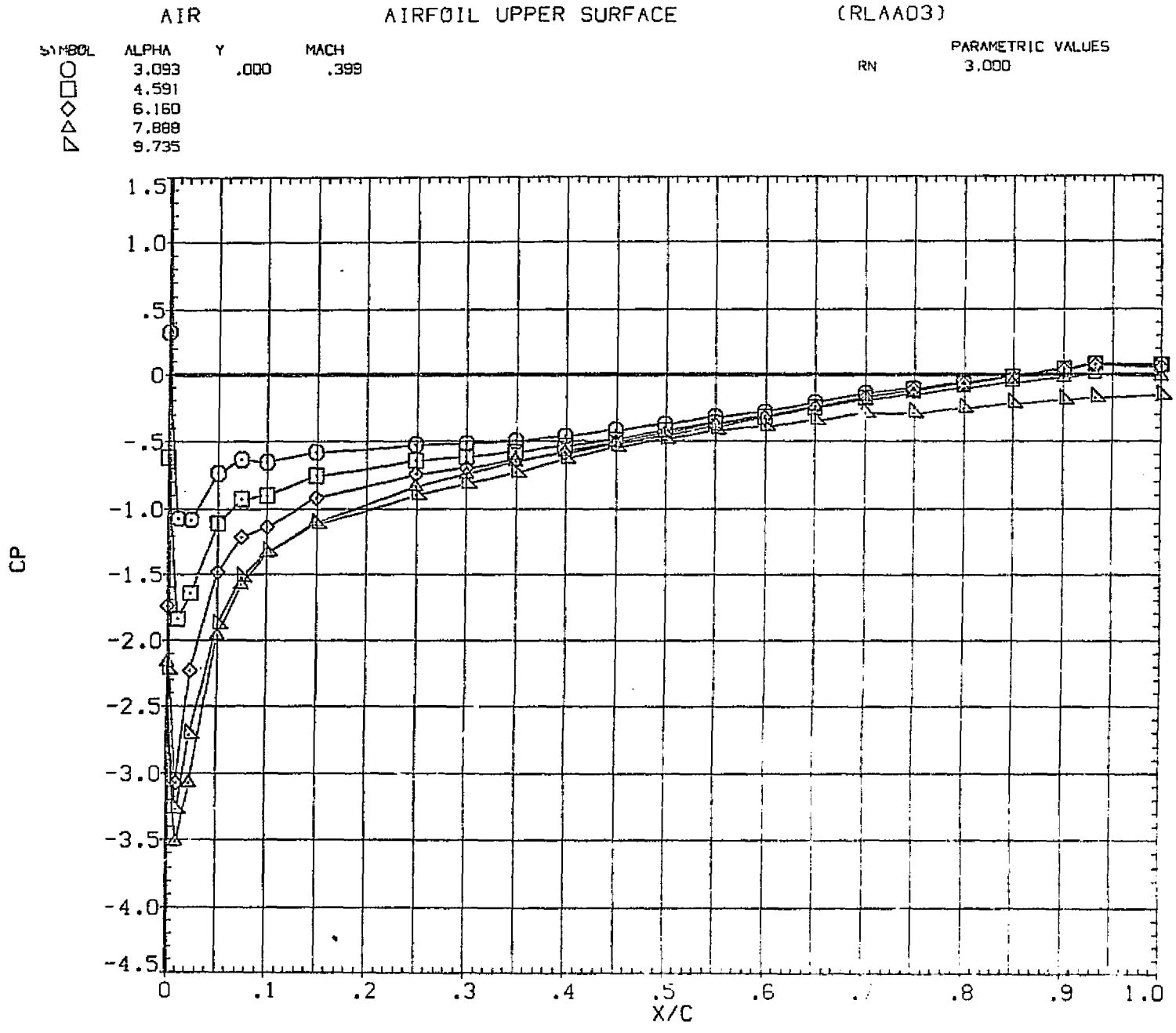


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

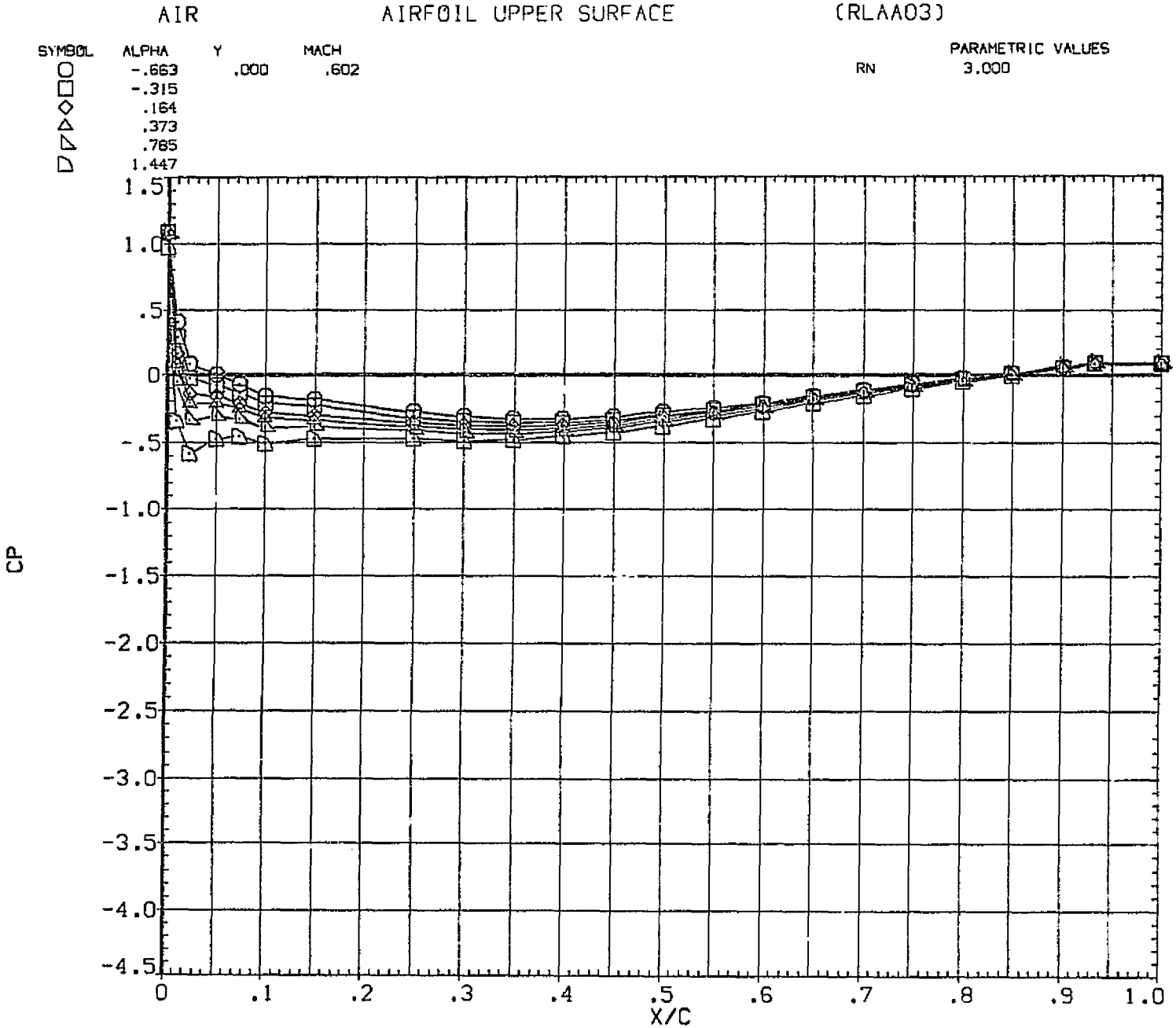


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

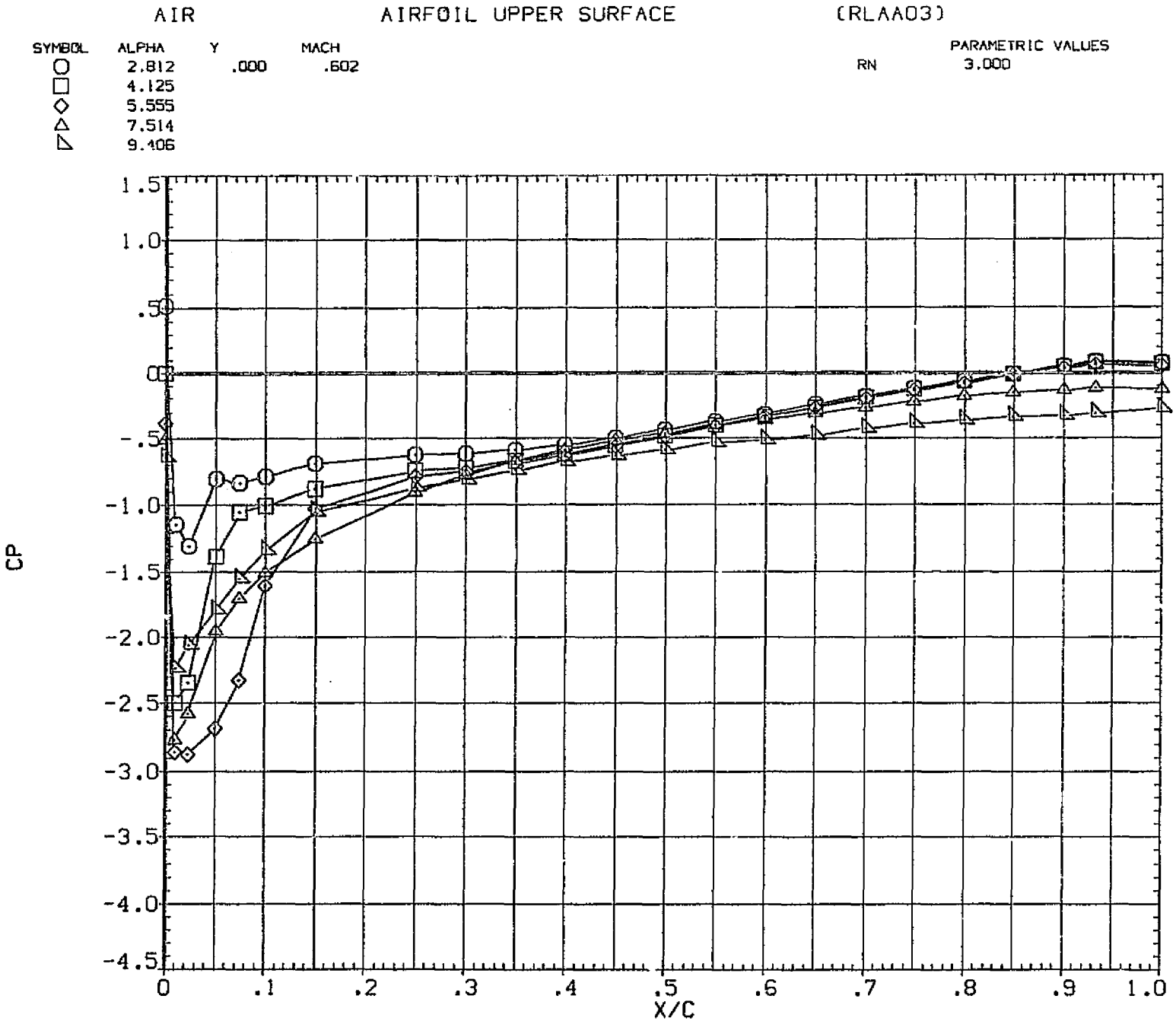


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

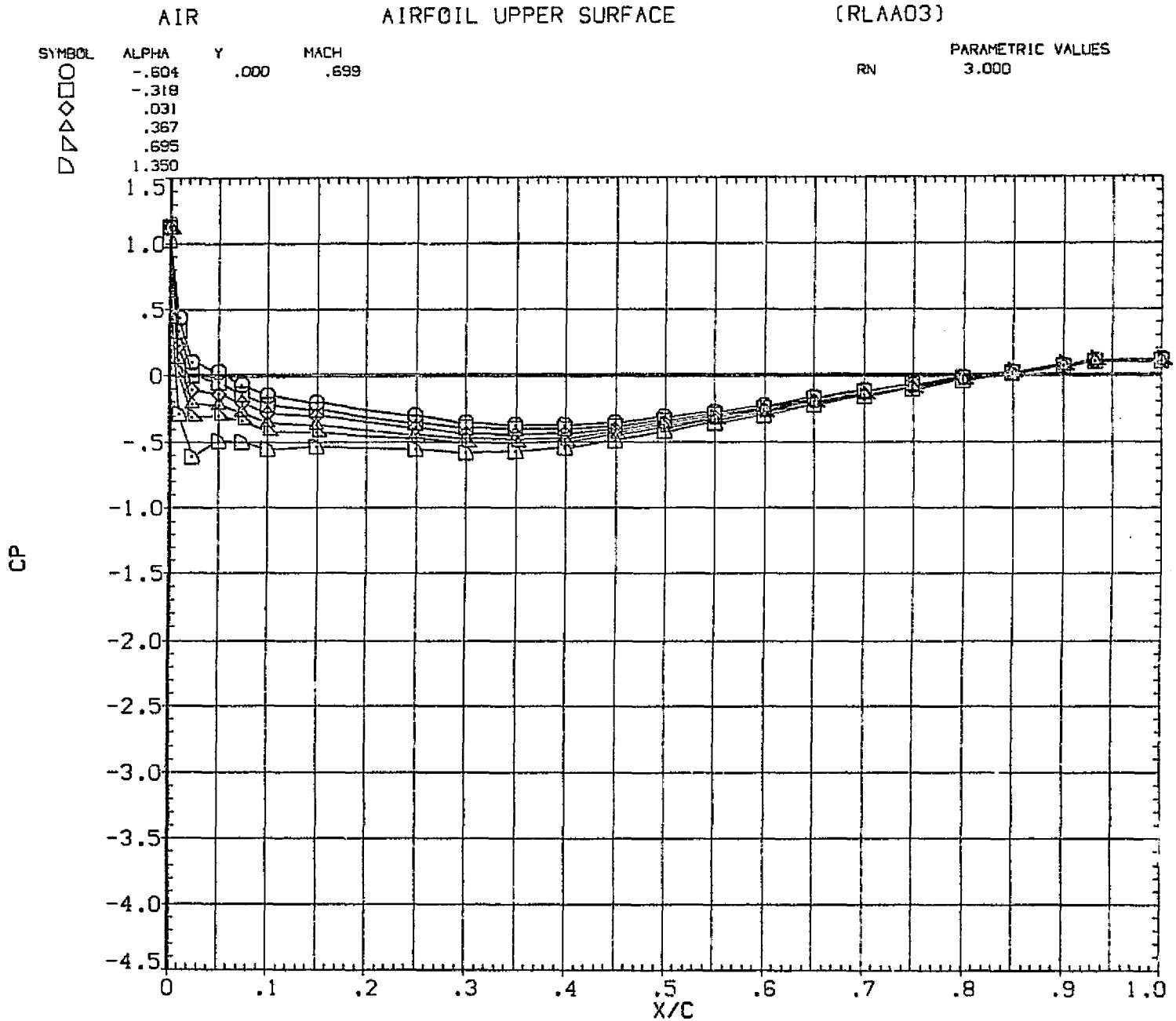


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

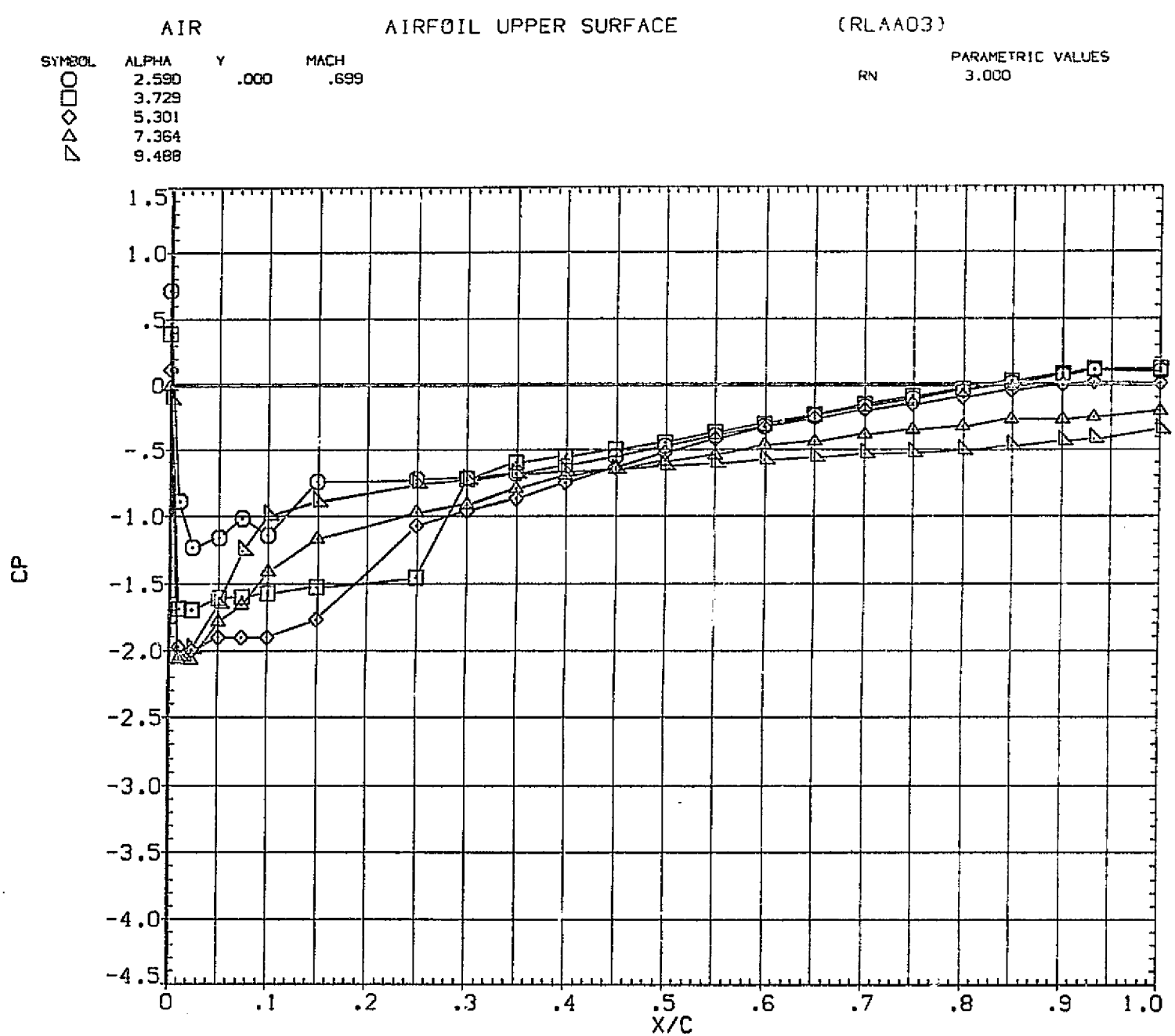


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

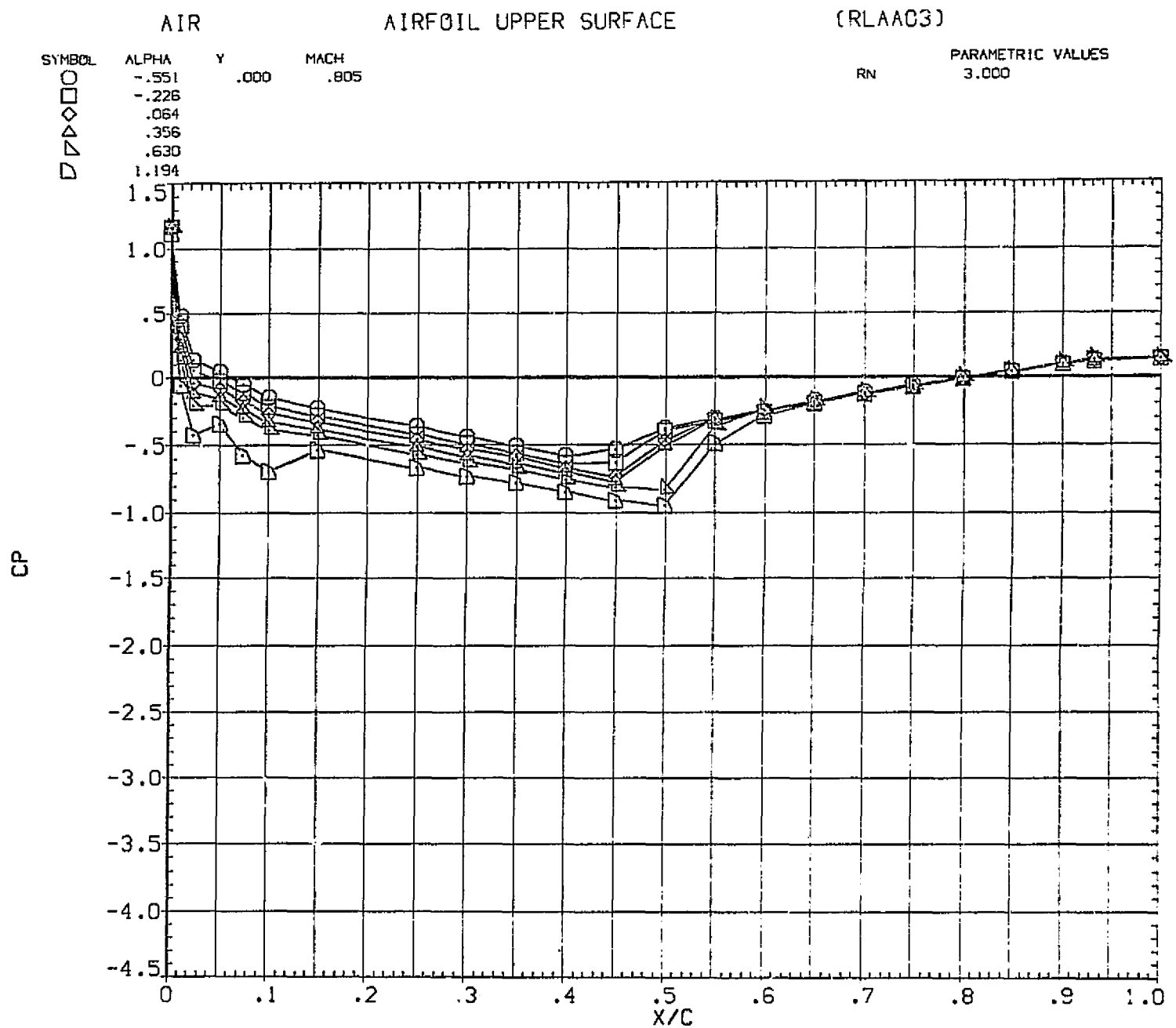


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

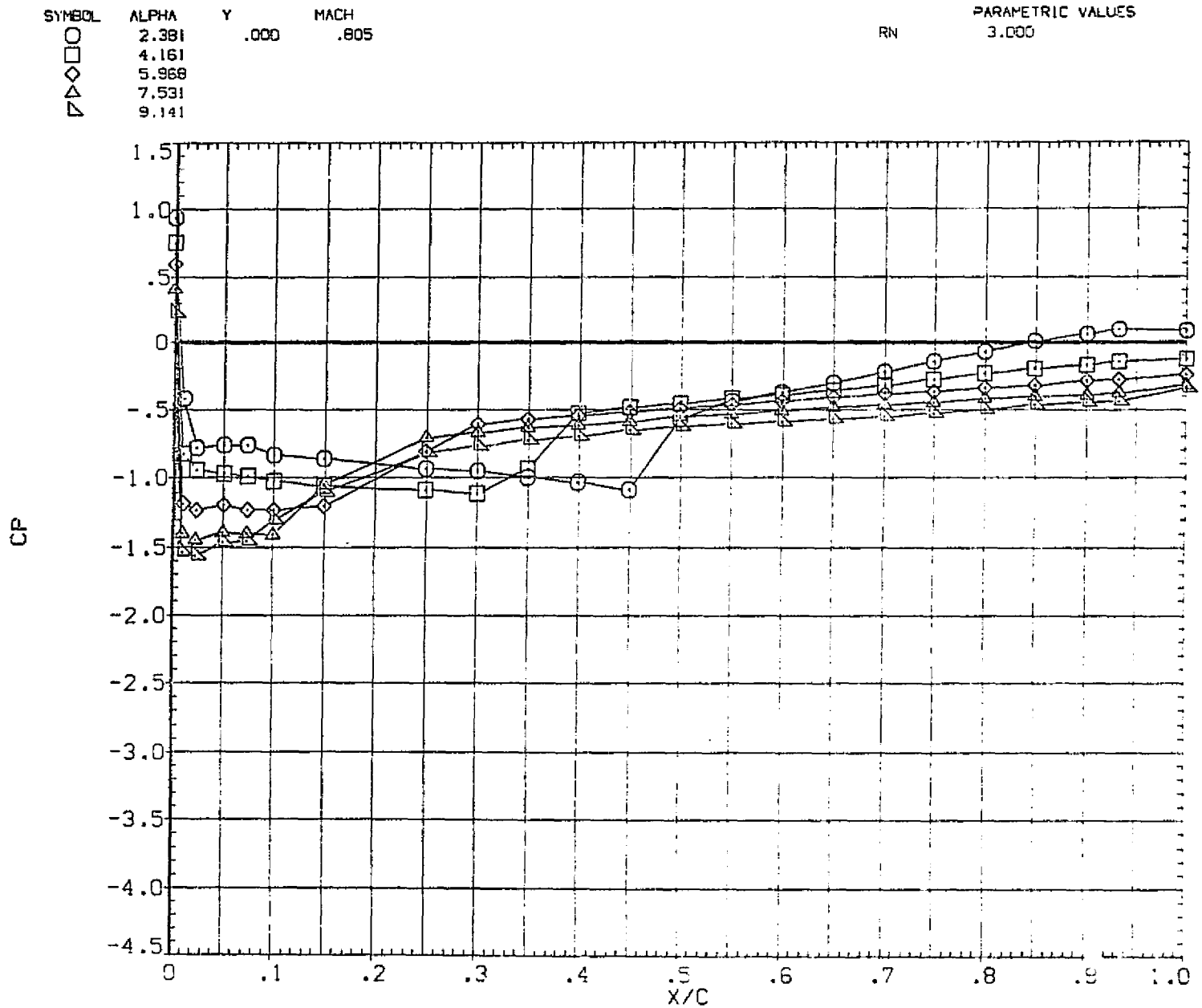


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

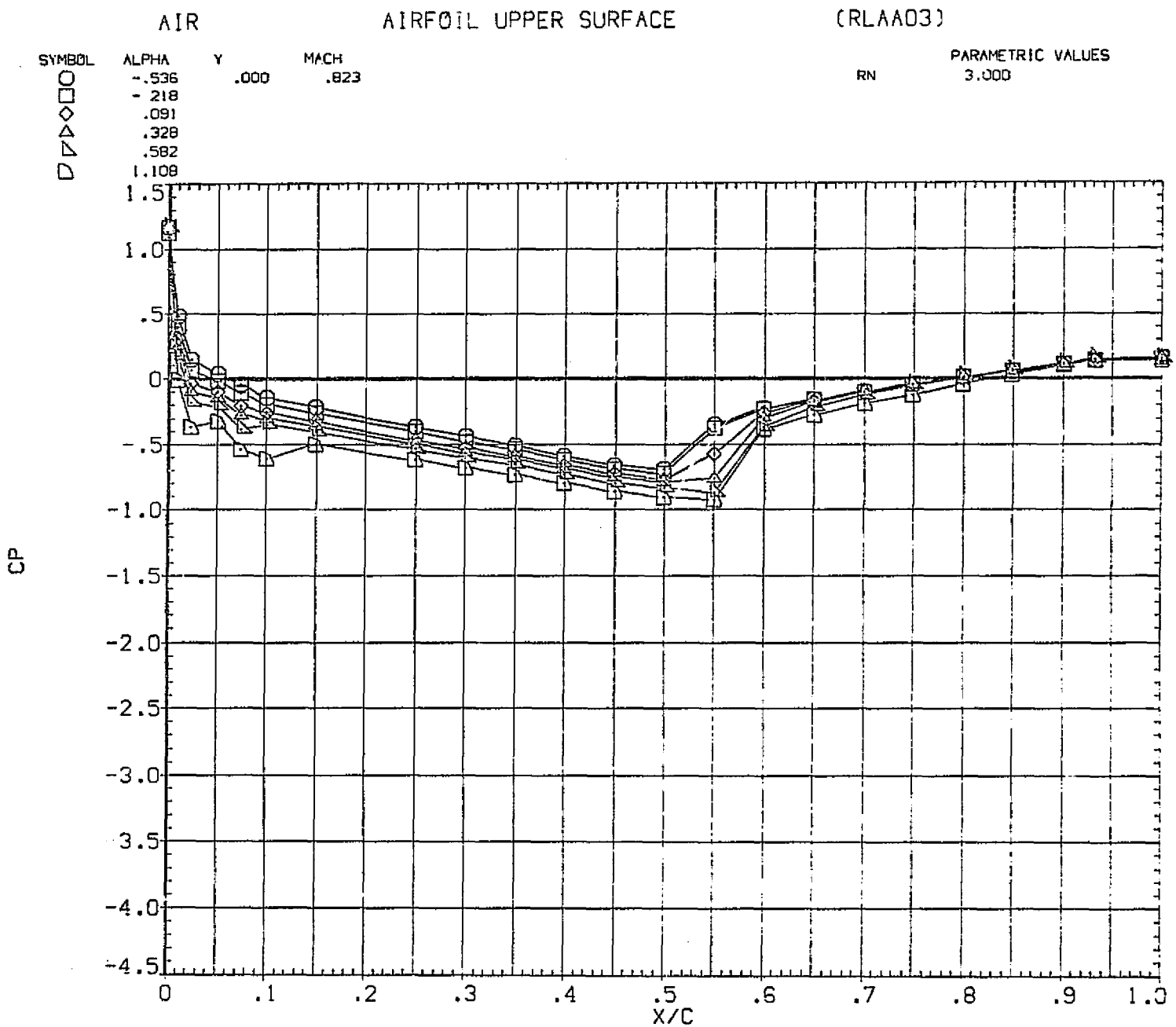


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

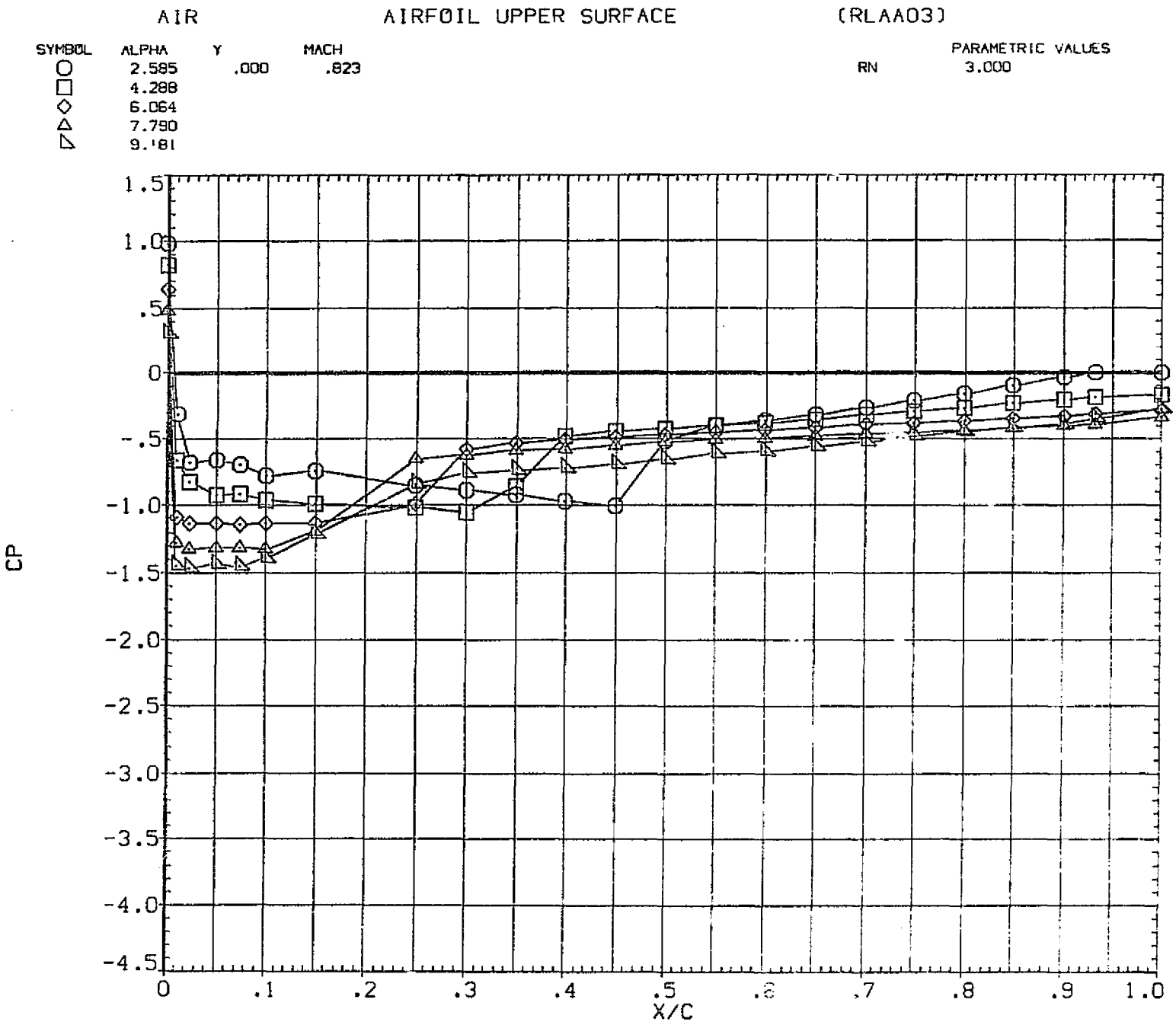


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

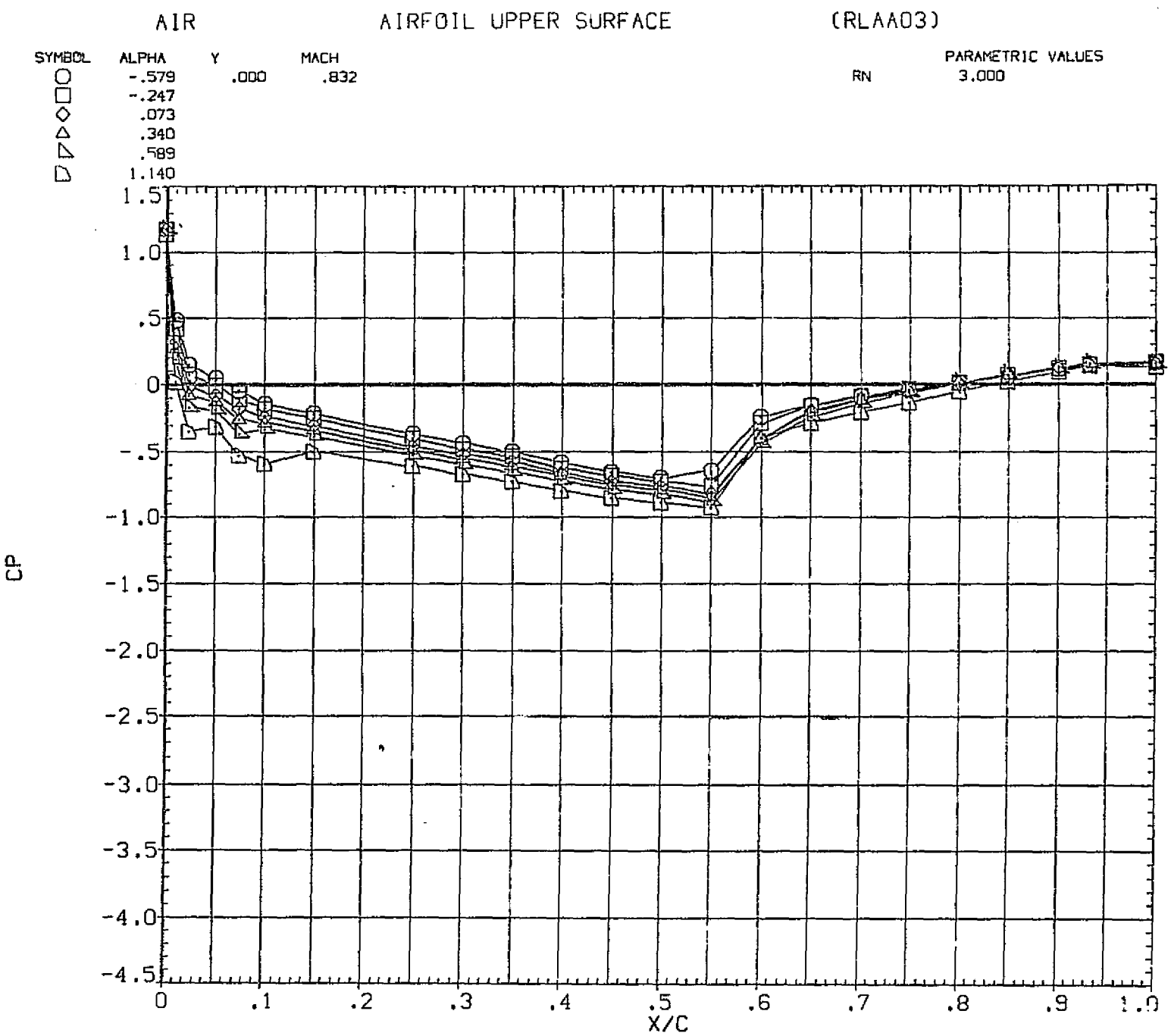


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

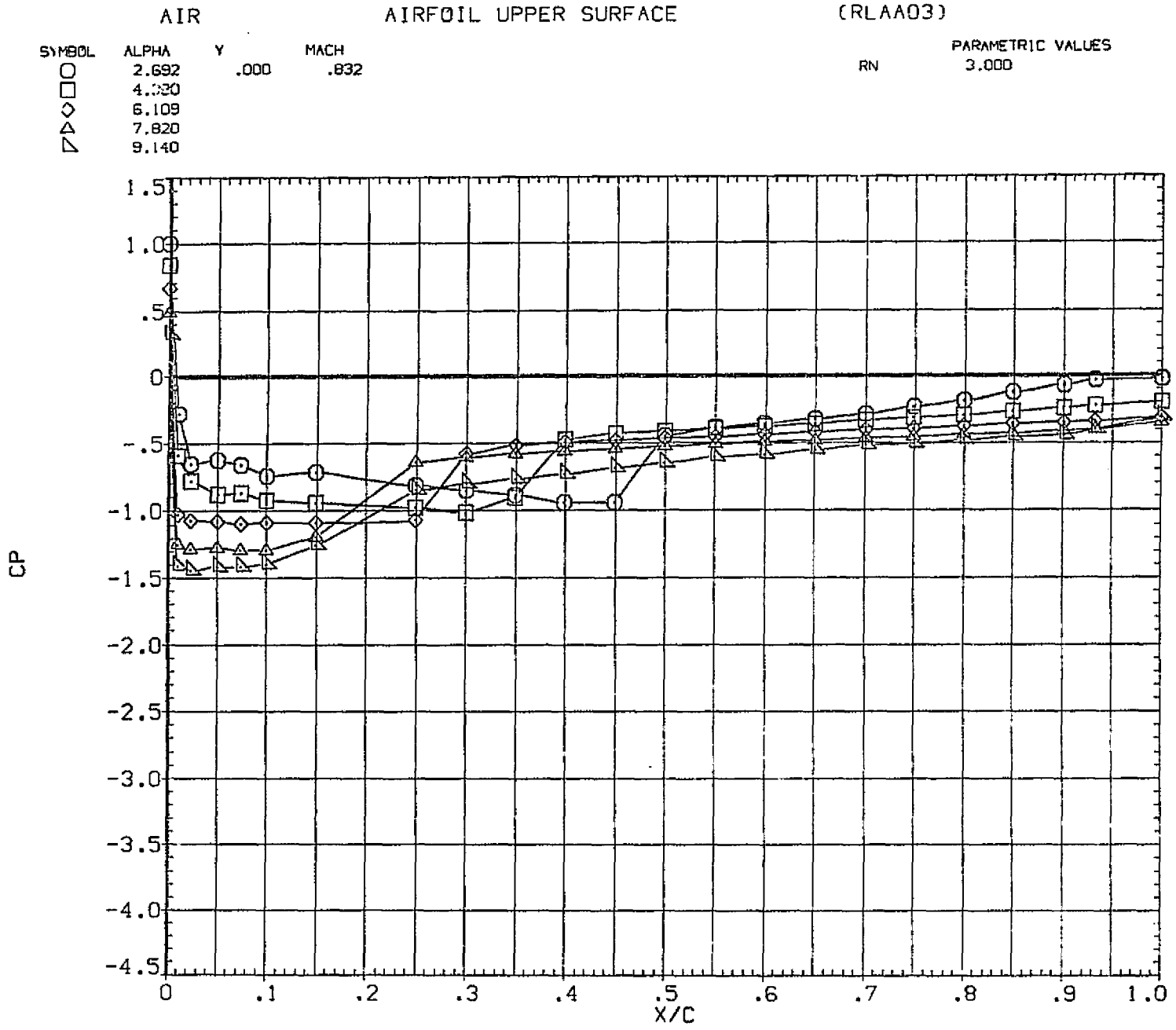


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

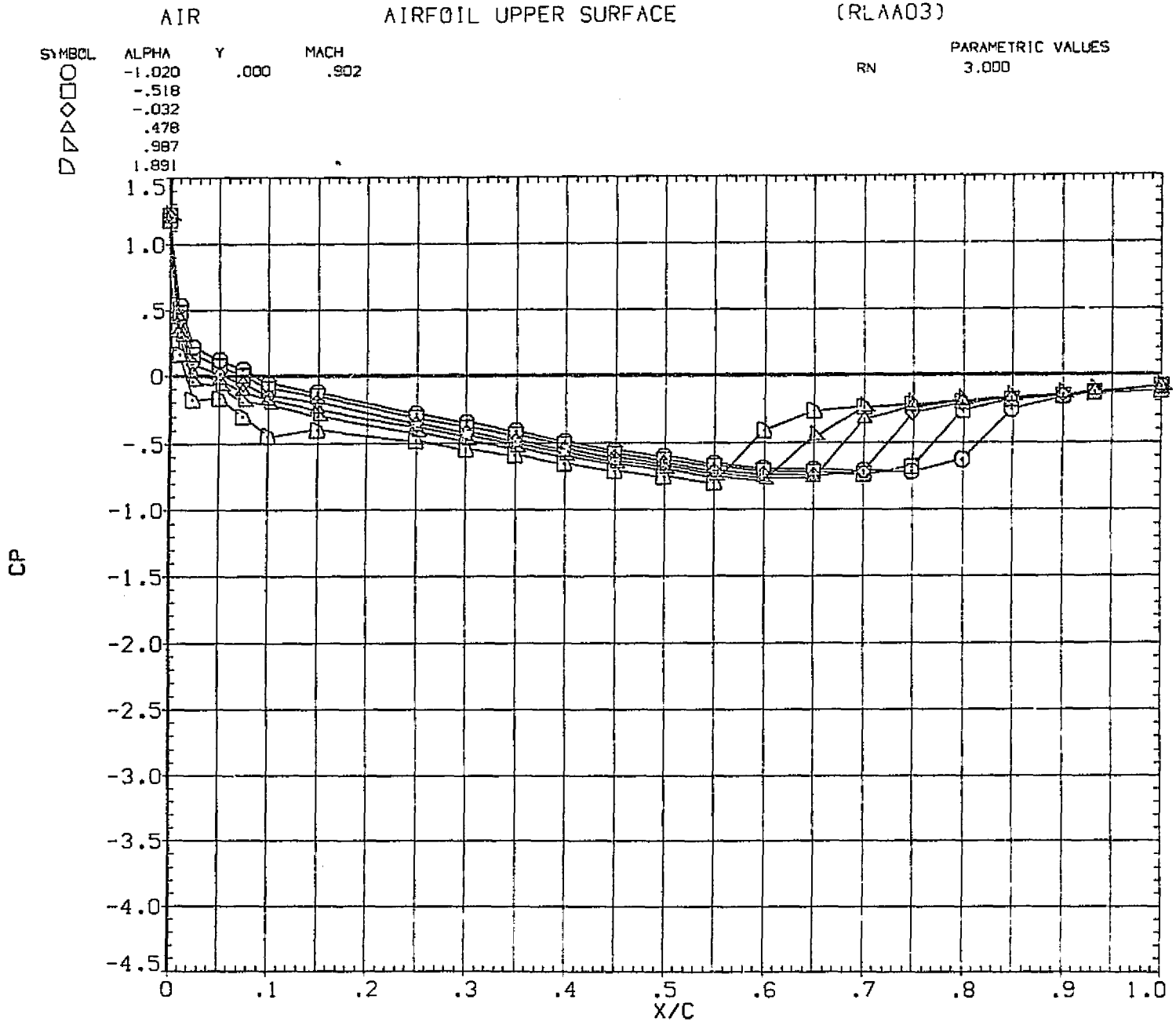


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL UPPER SURFACE (RLAA03)

SYMBOL	ALPHA	Y	MACH
○	2.736	.000	.902
□	3.489		
◇	4.987		
△	6.193		

PARAMETRIC VALUES
RN 3.000

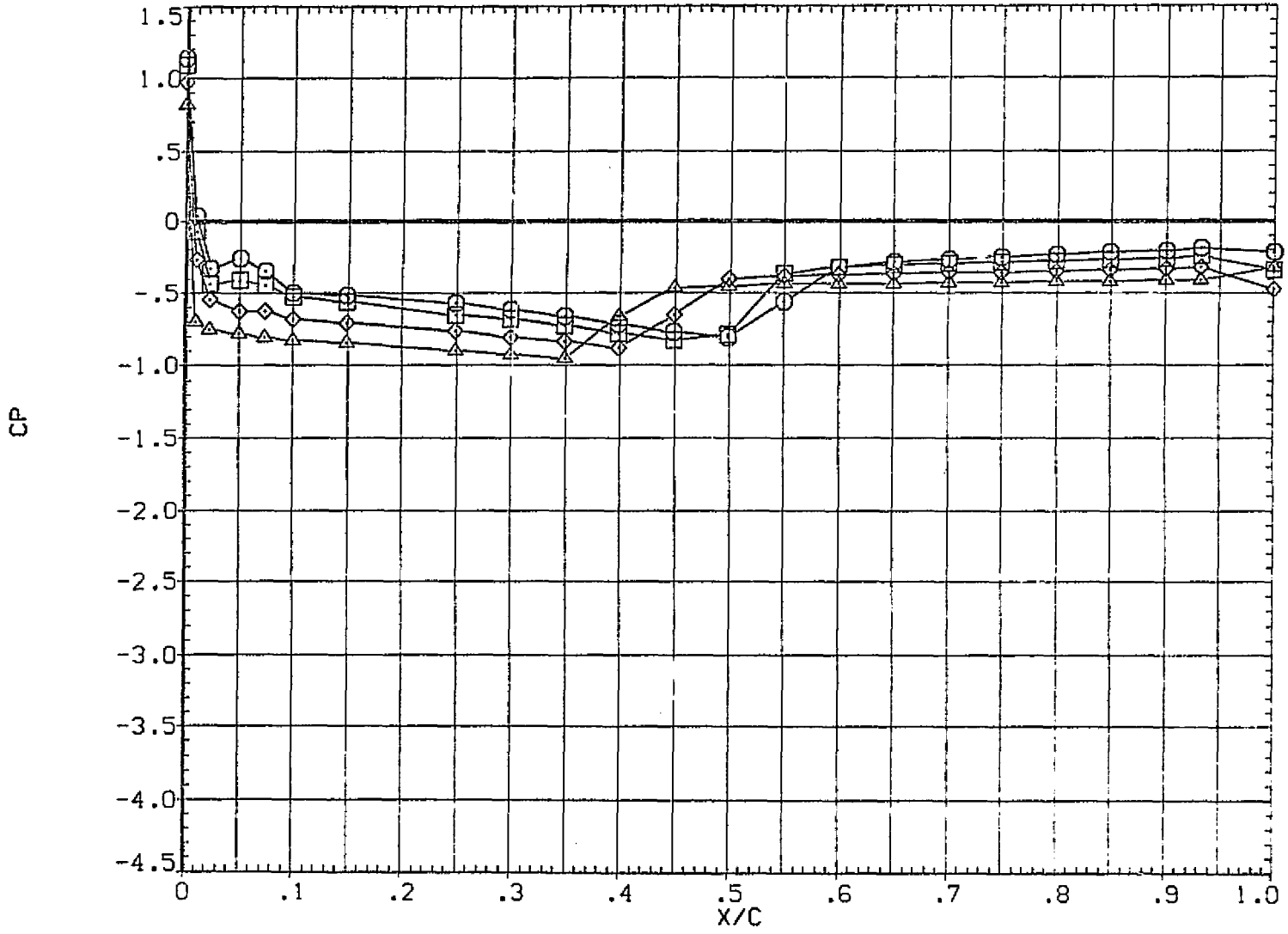


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

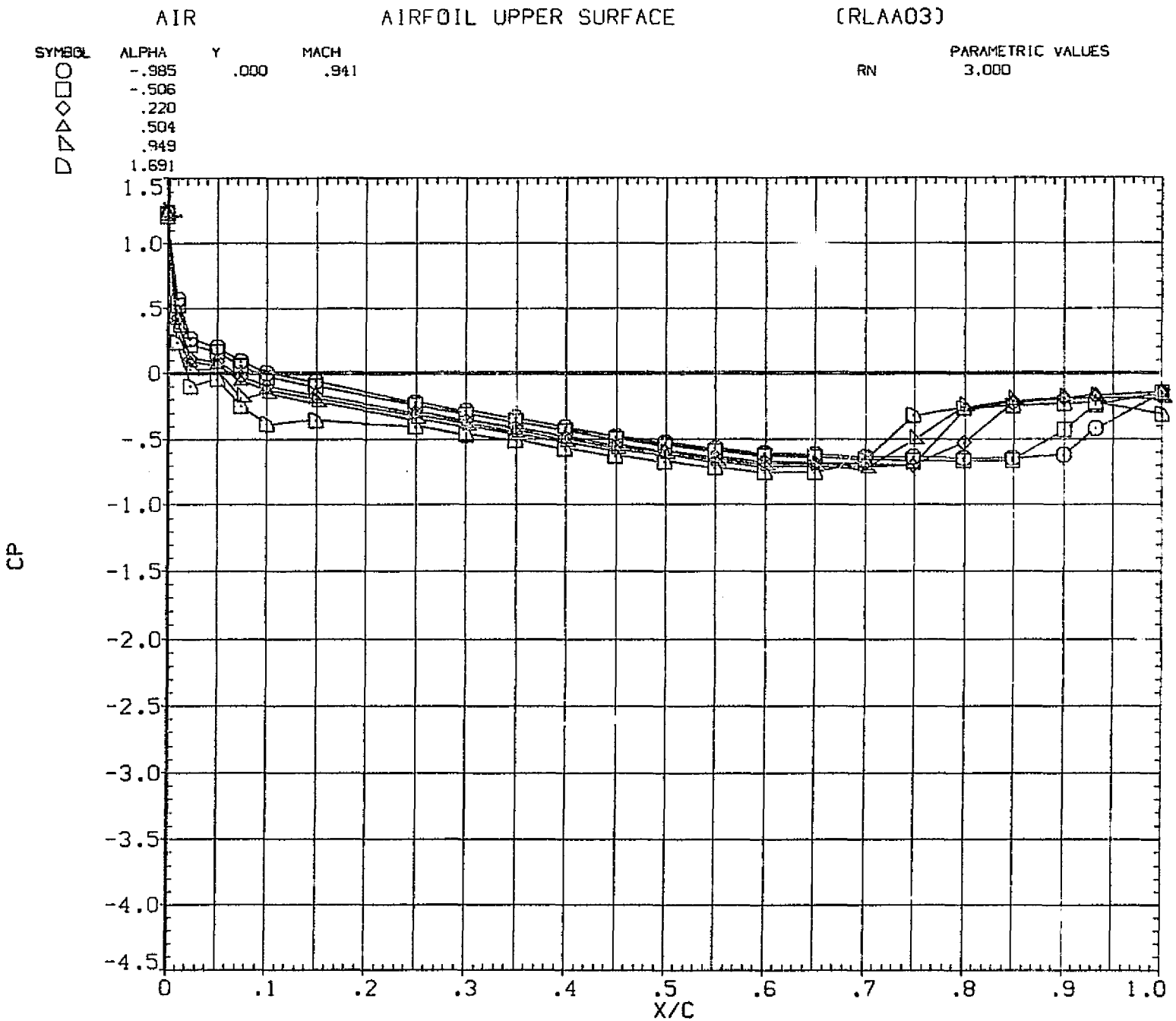


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL UPPER SURFACE (RLAA03)

SYMBOL	ALPHA	Y	MACH
○	3.185	.000	.941
□	4.792		

PARAMETRIC VALUES
RN 3.000

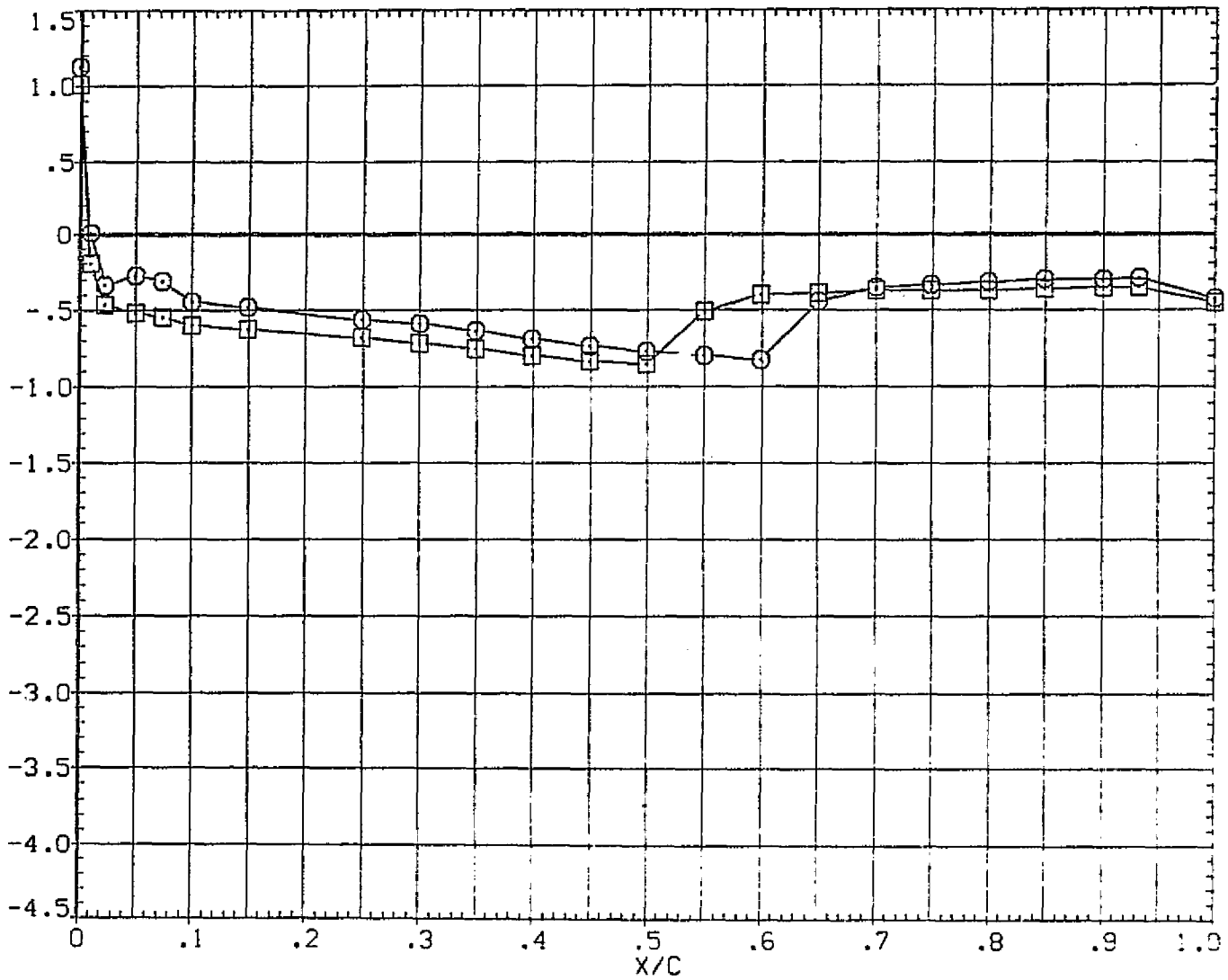


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

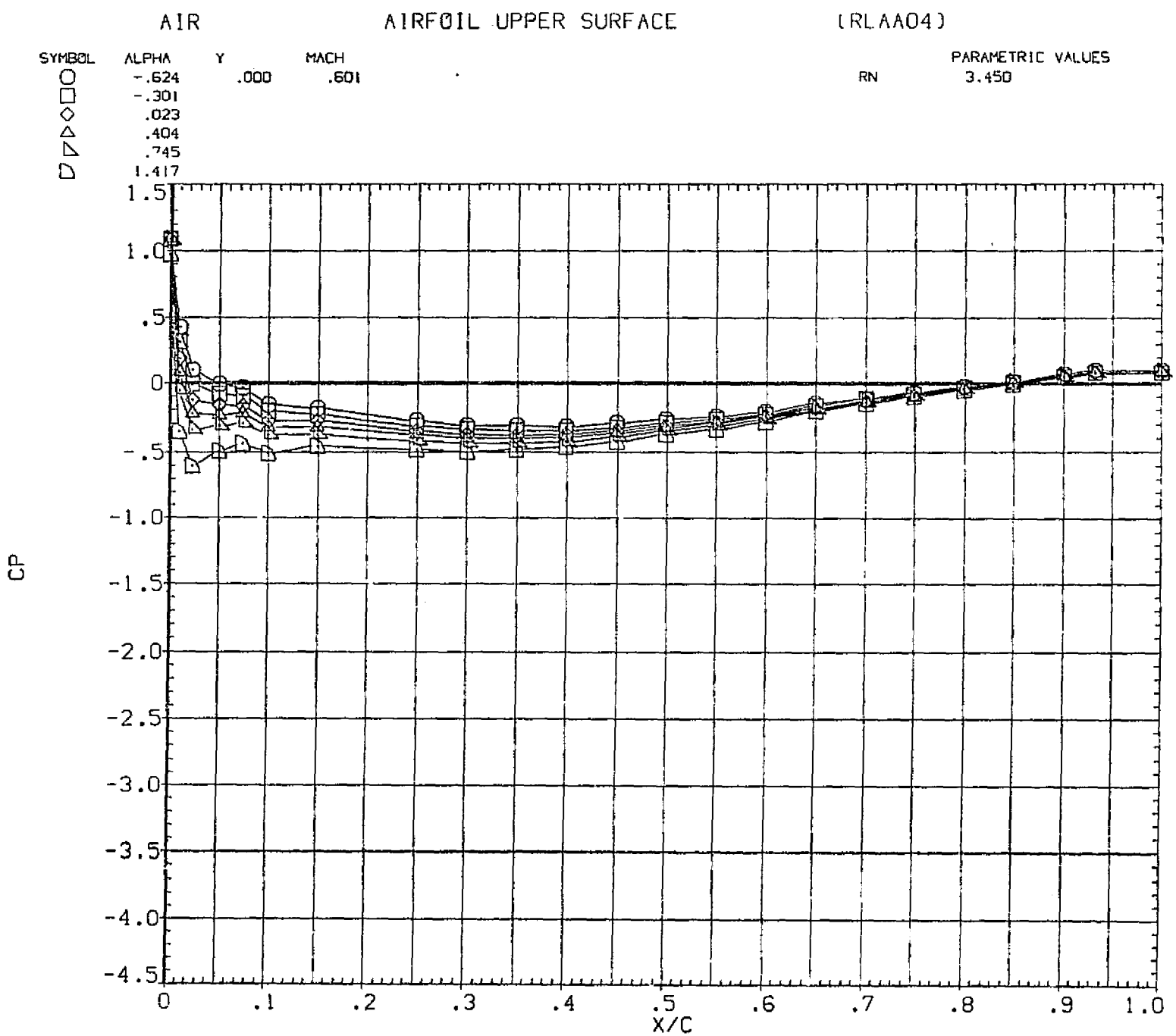


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

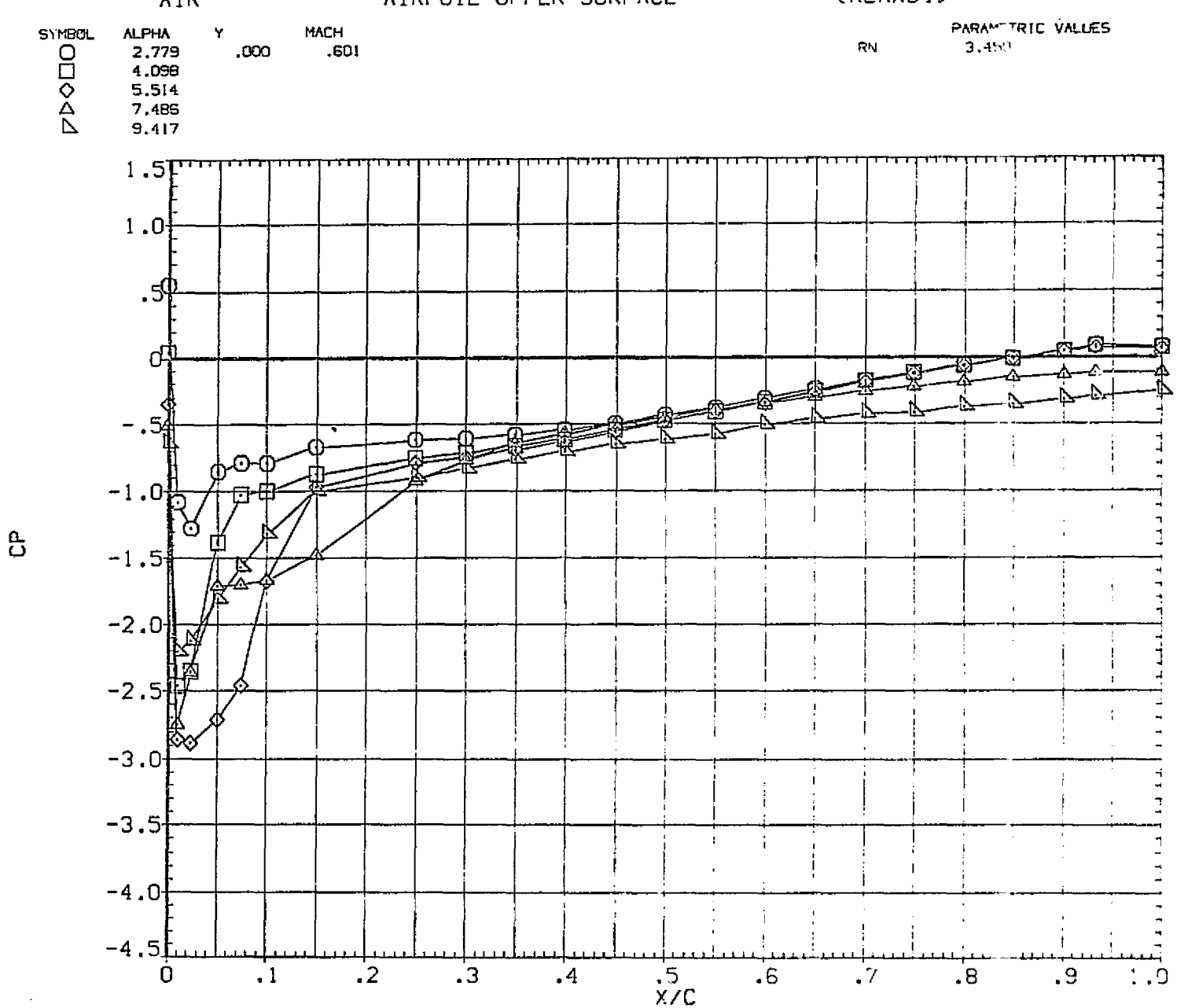


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

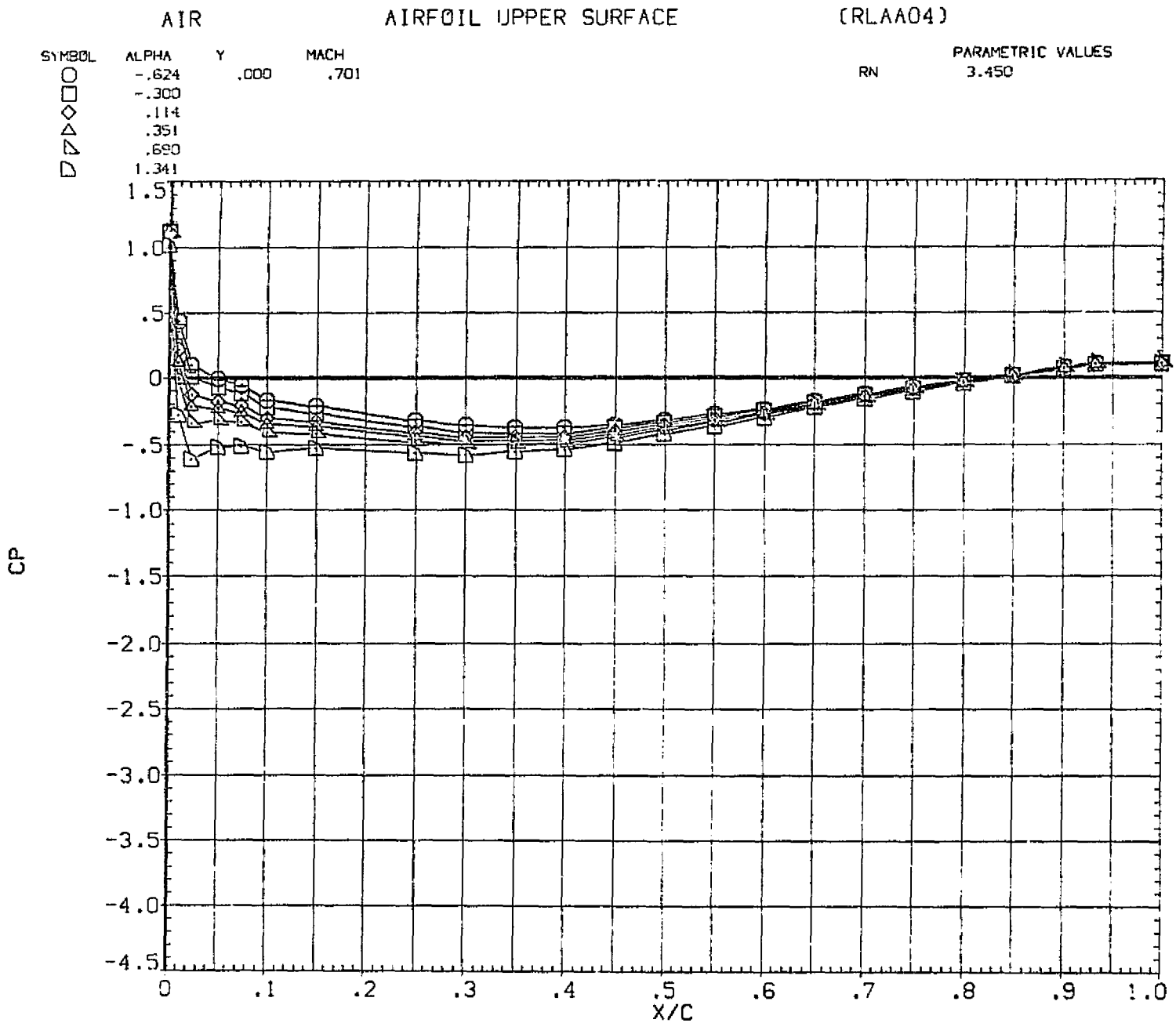


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

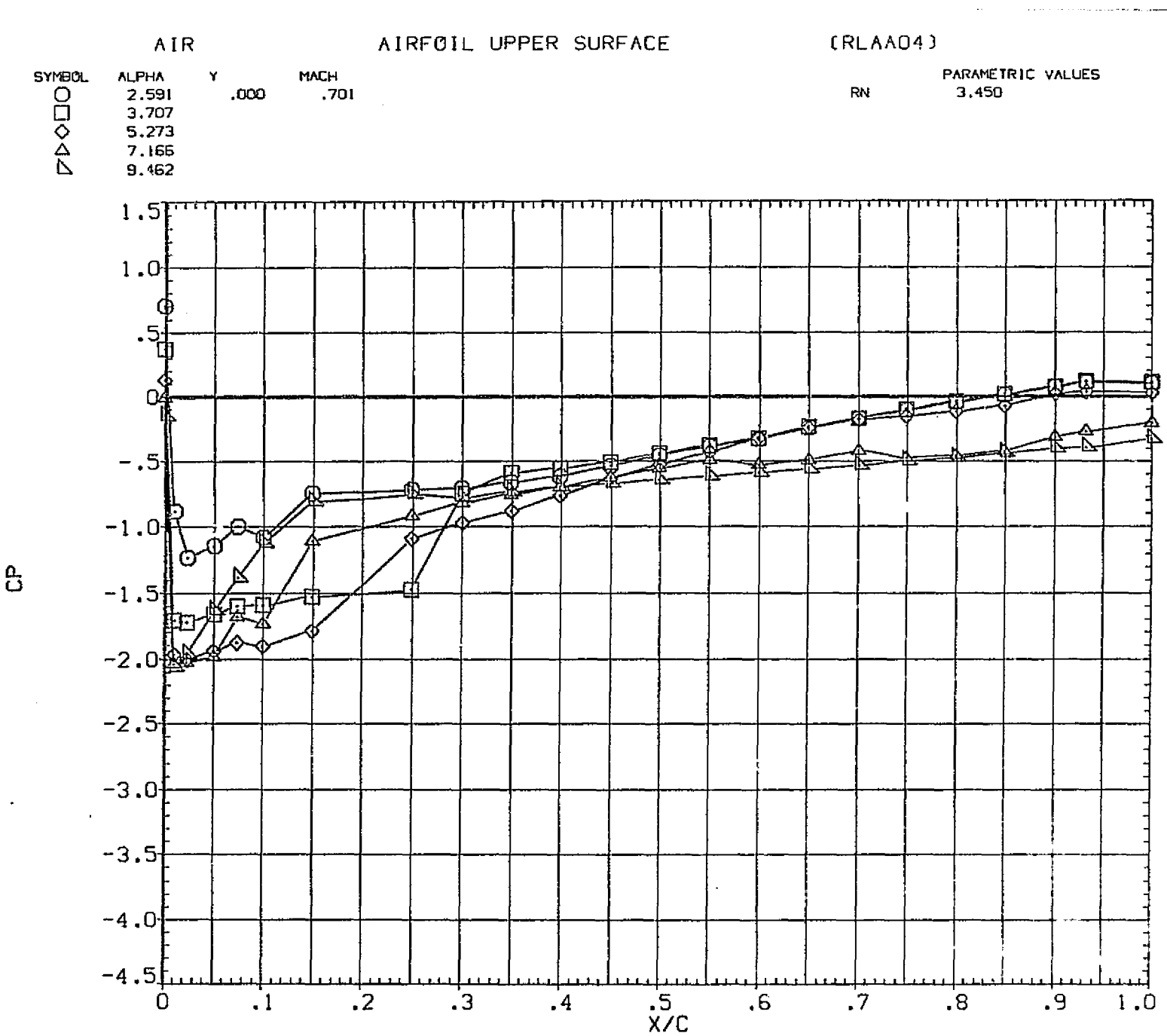


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

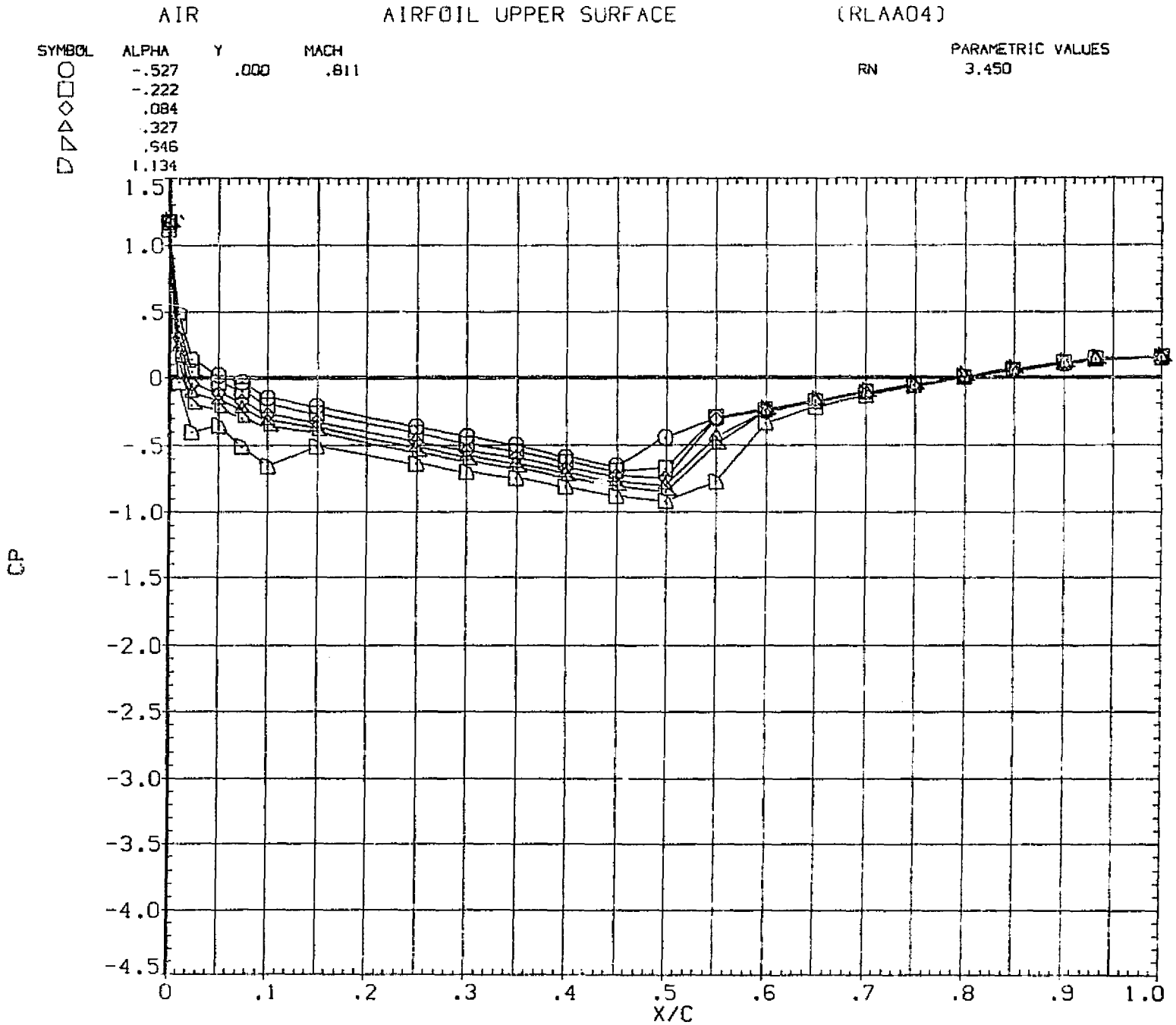


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

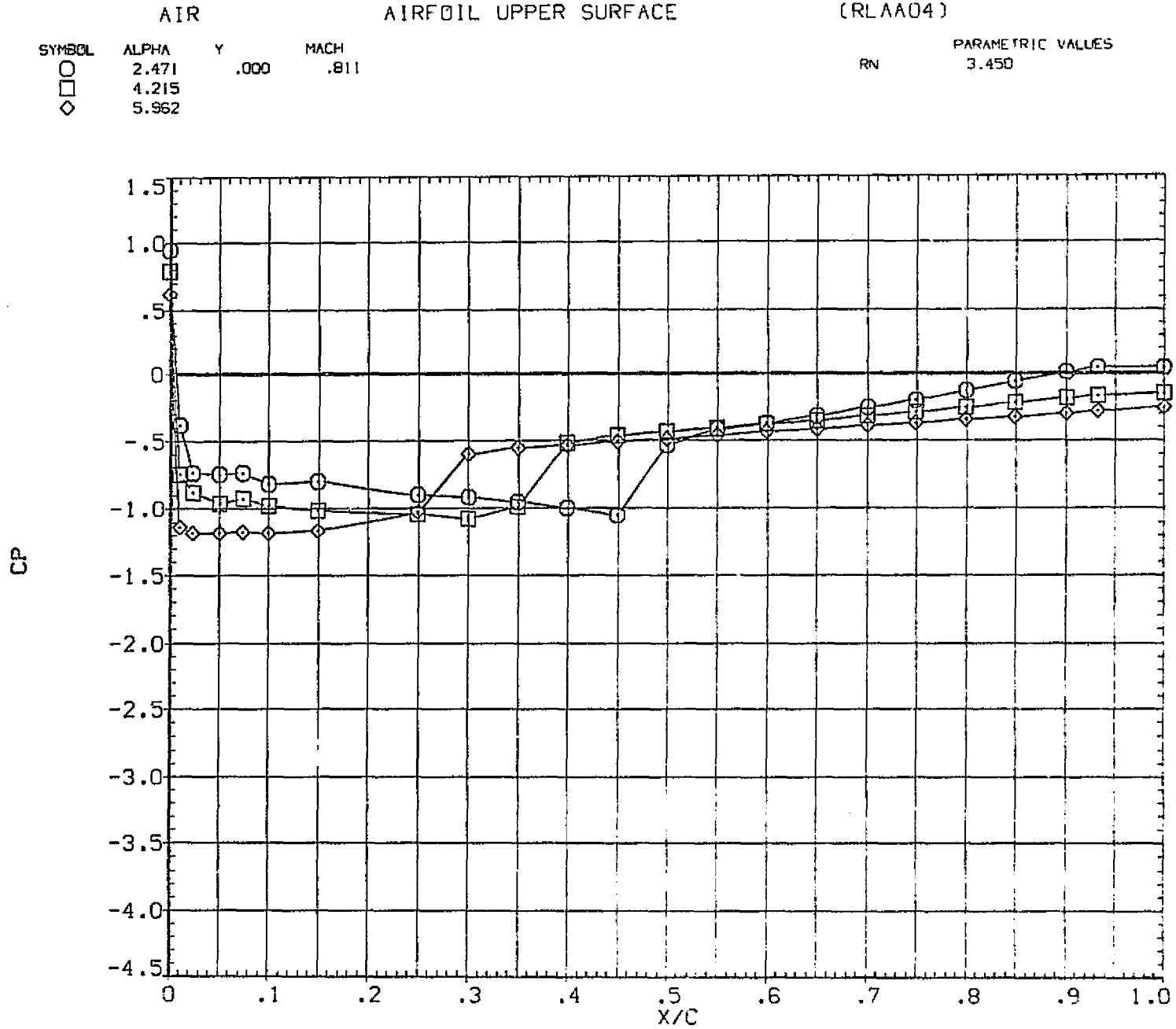


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

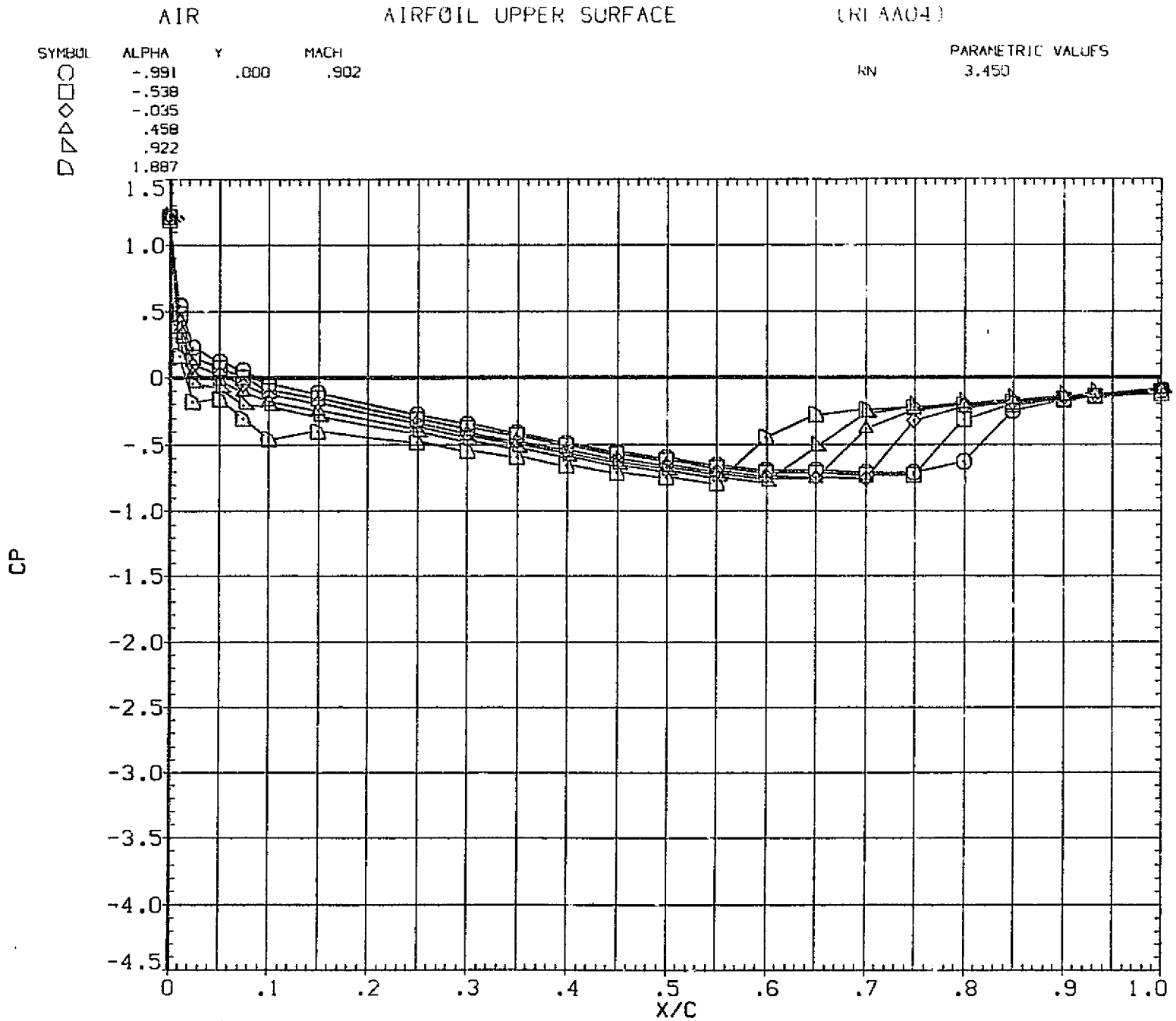


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL UPPER SURFACE (RLAA04)

SYMBOL	ALPHA	Y	MACH
○	3.432	.000	.902
□	4.978		

PARAMETRIC VALUES
RN 3.450

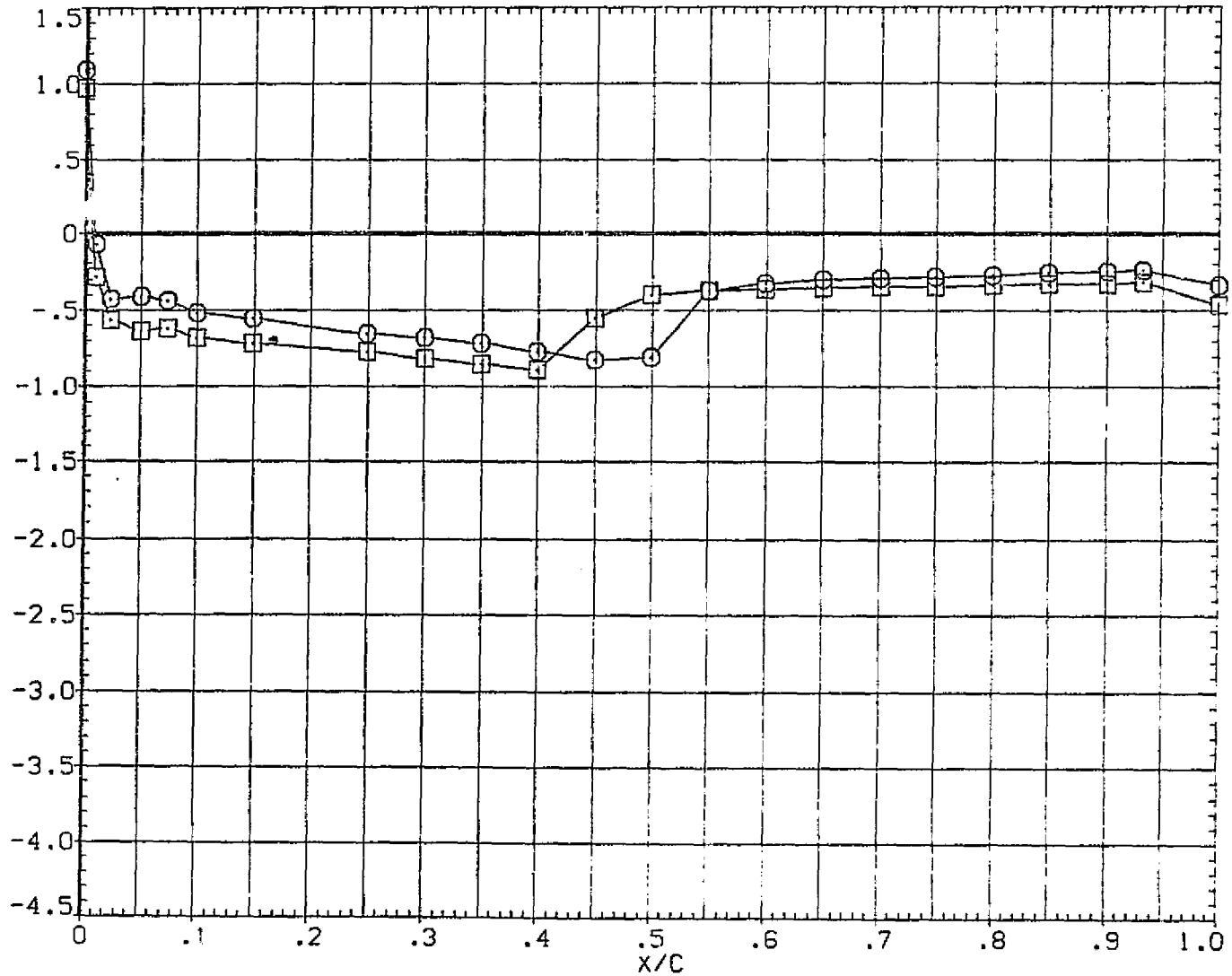


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

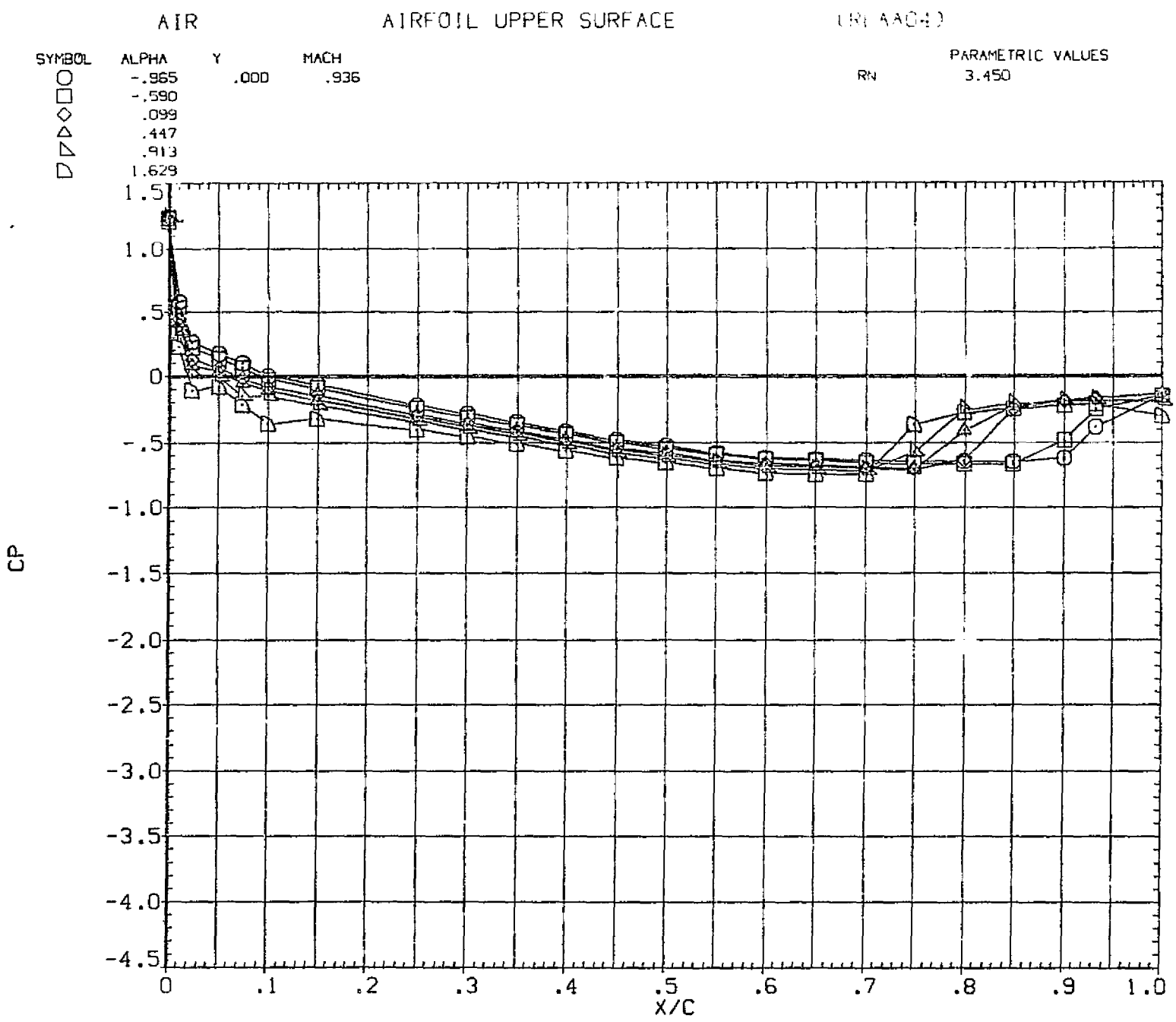


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL UPPER SURFACE (RLAA04)

SYMBOL	ALPHA	Y	MACH
○	3.175	.000	.936
□	4.775		

PARAMETRIC VALUES

RN 3.450

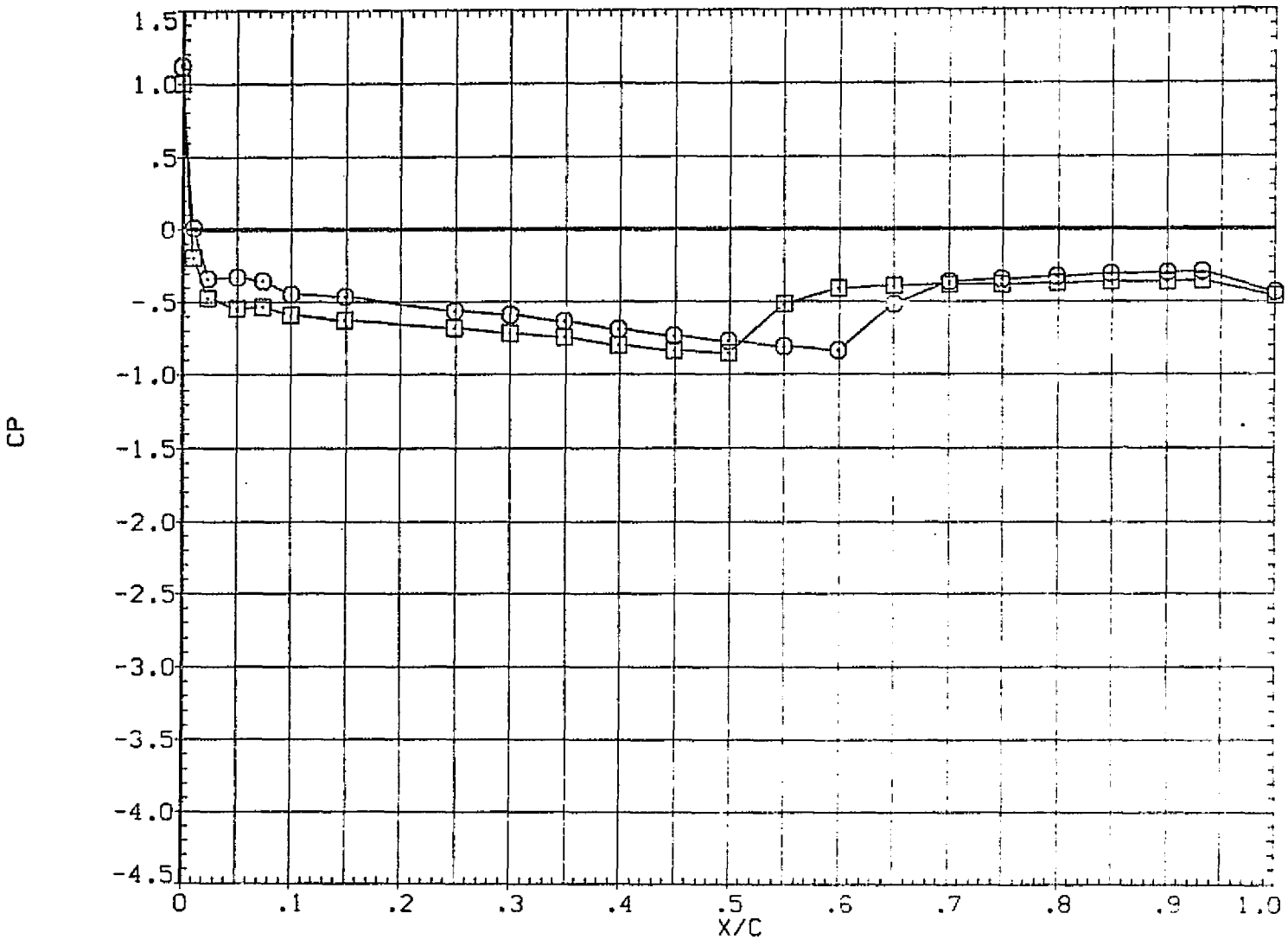


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

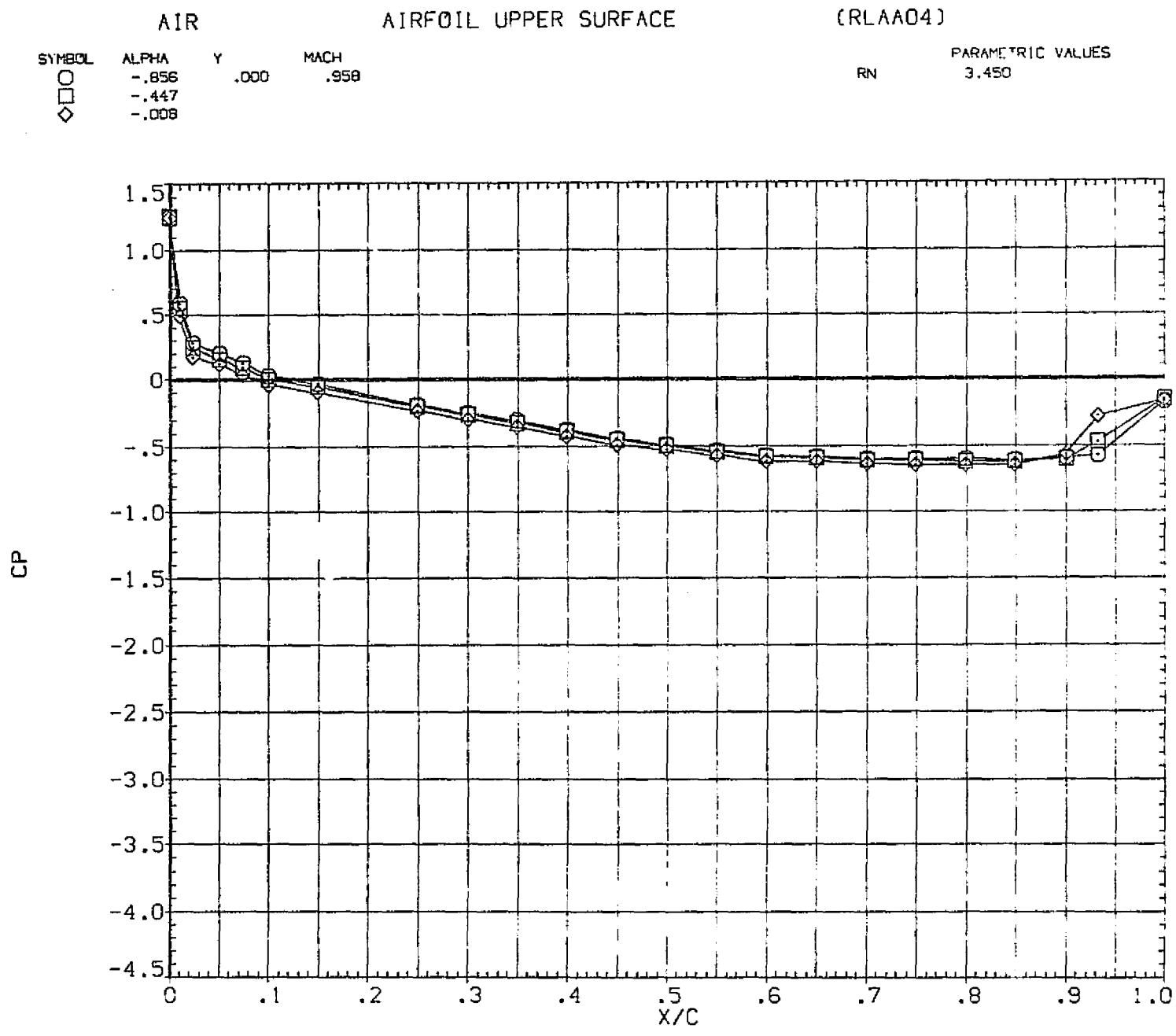


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

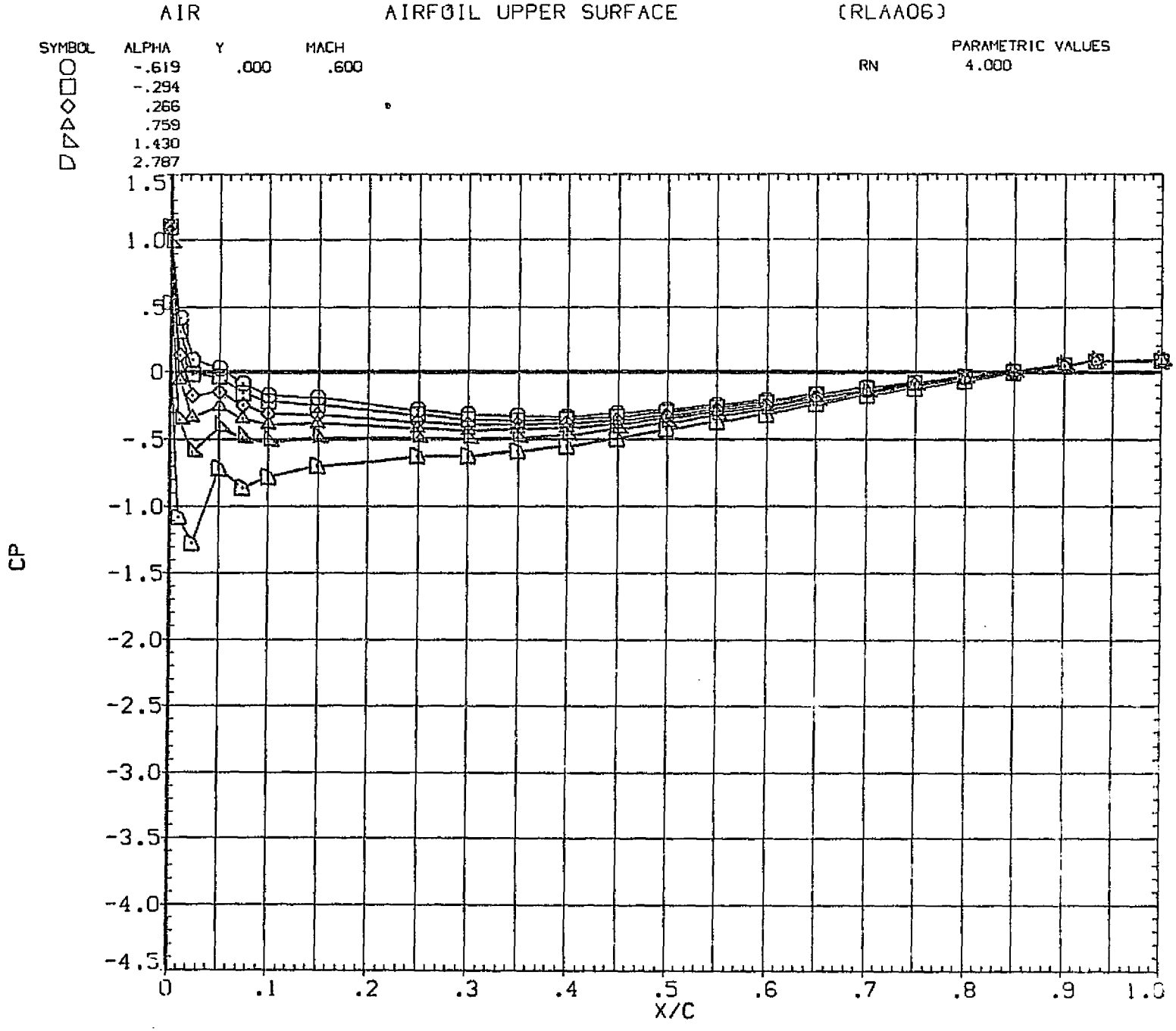


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

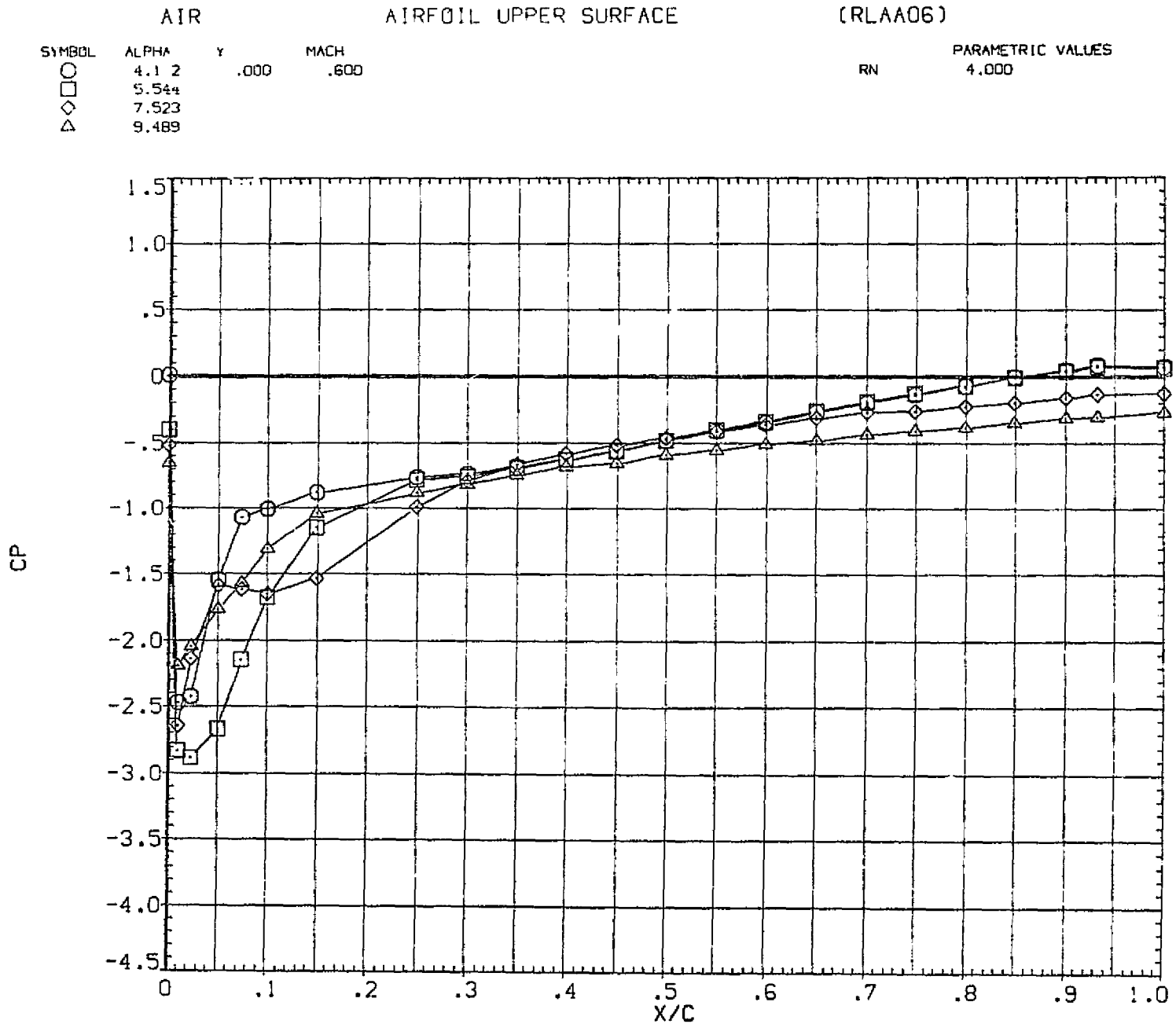


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

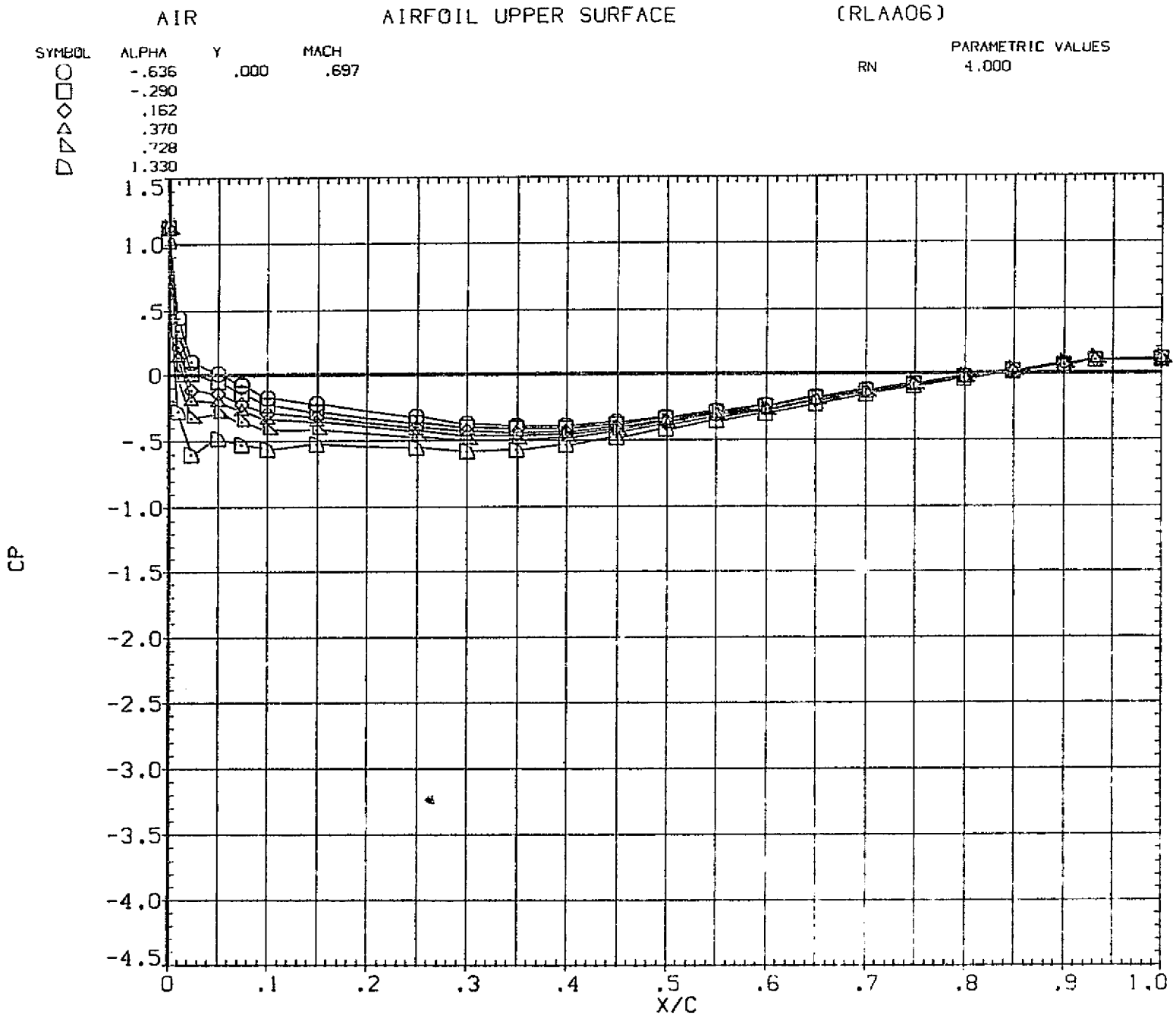


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

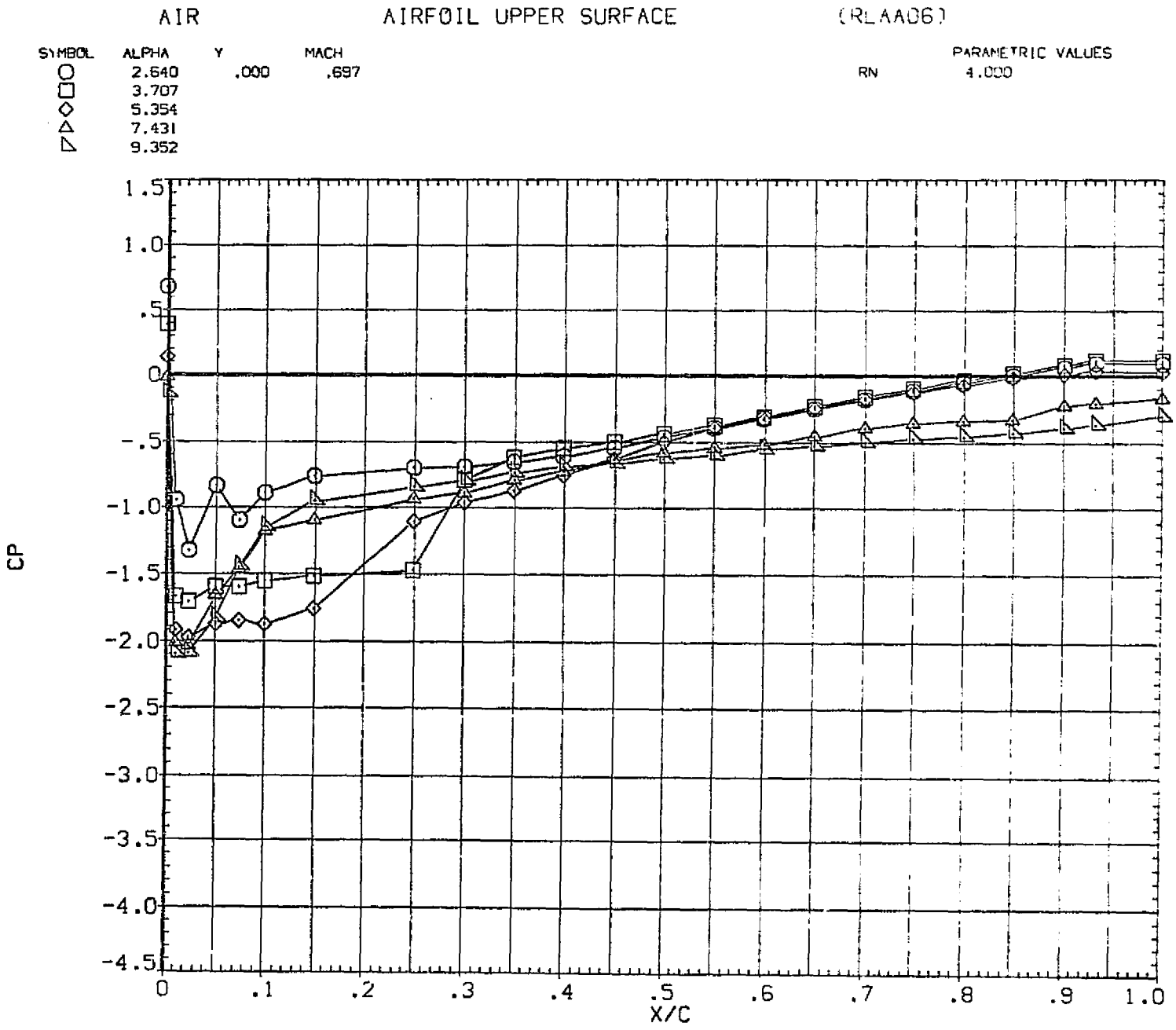


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

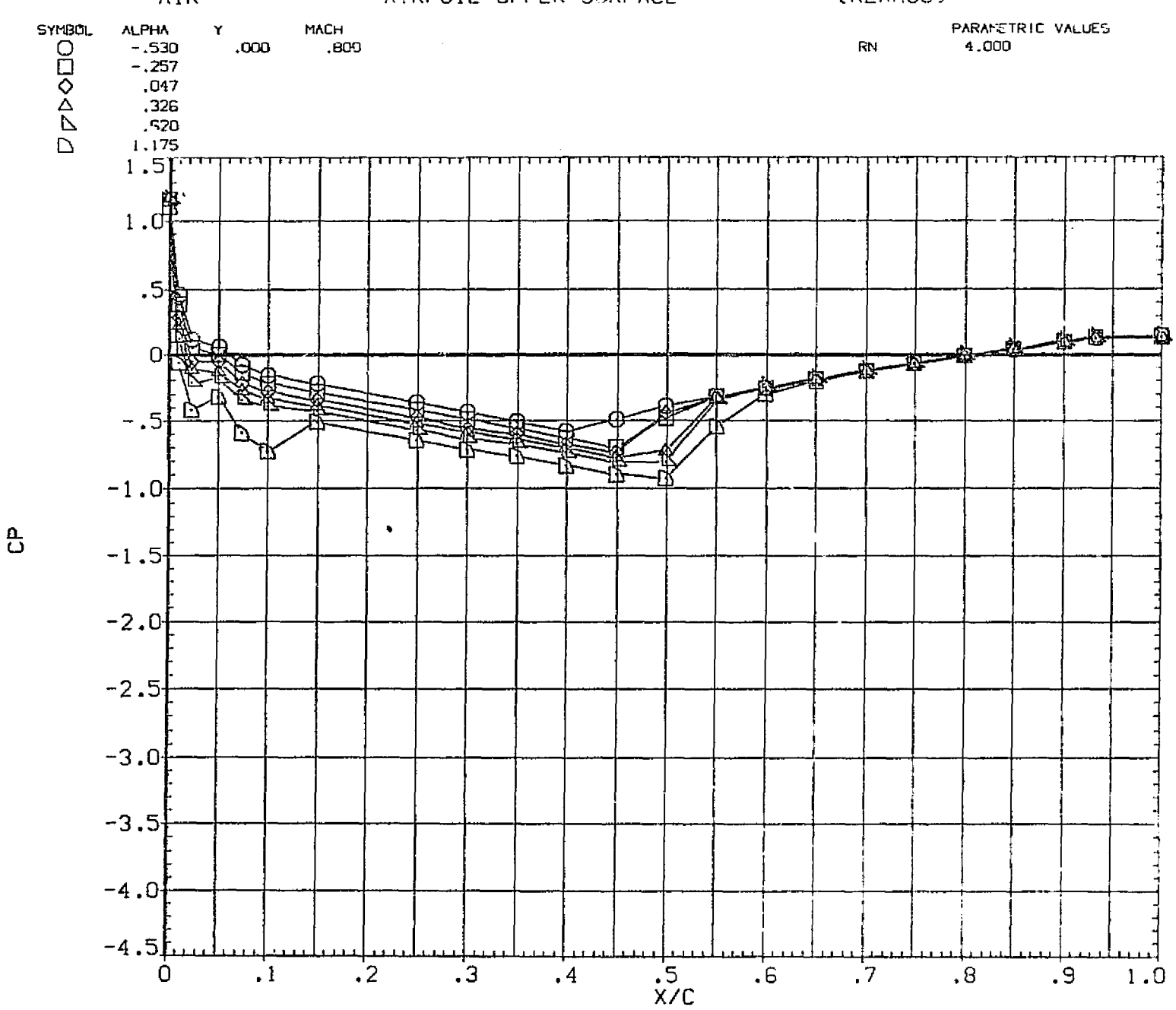


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL UPPER SURFACE (RLAA06)

SYMBOL	ALPHA	Y	MACH
○	2.402	.000	.800

PARAMETRIC VALUES
RN 4.000

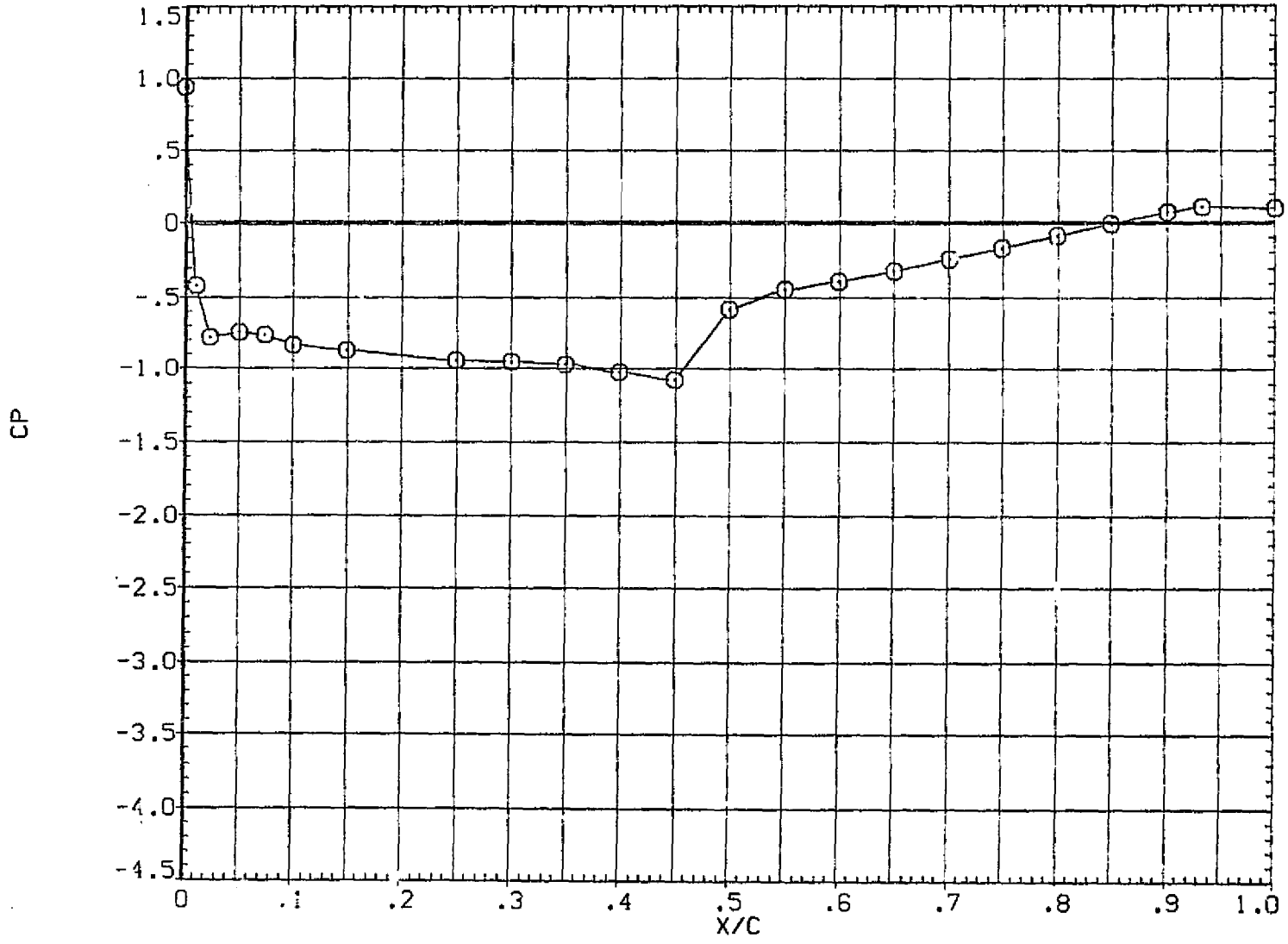


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

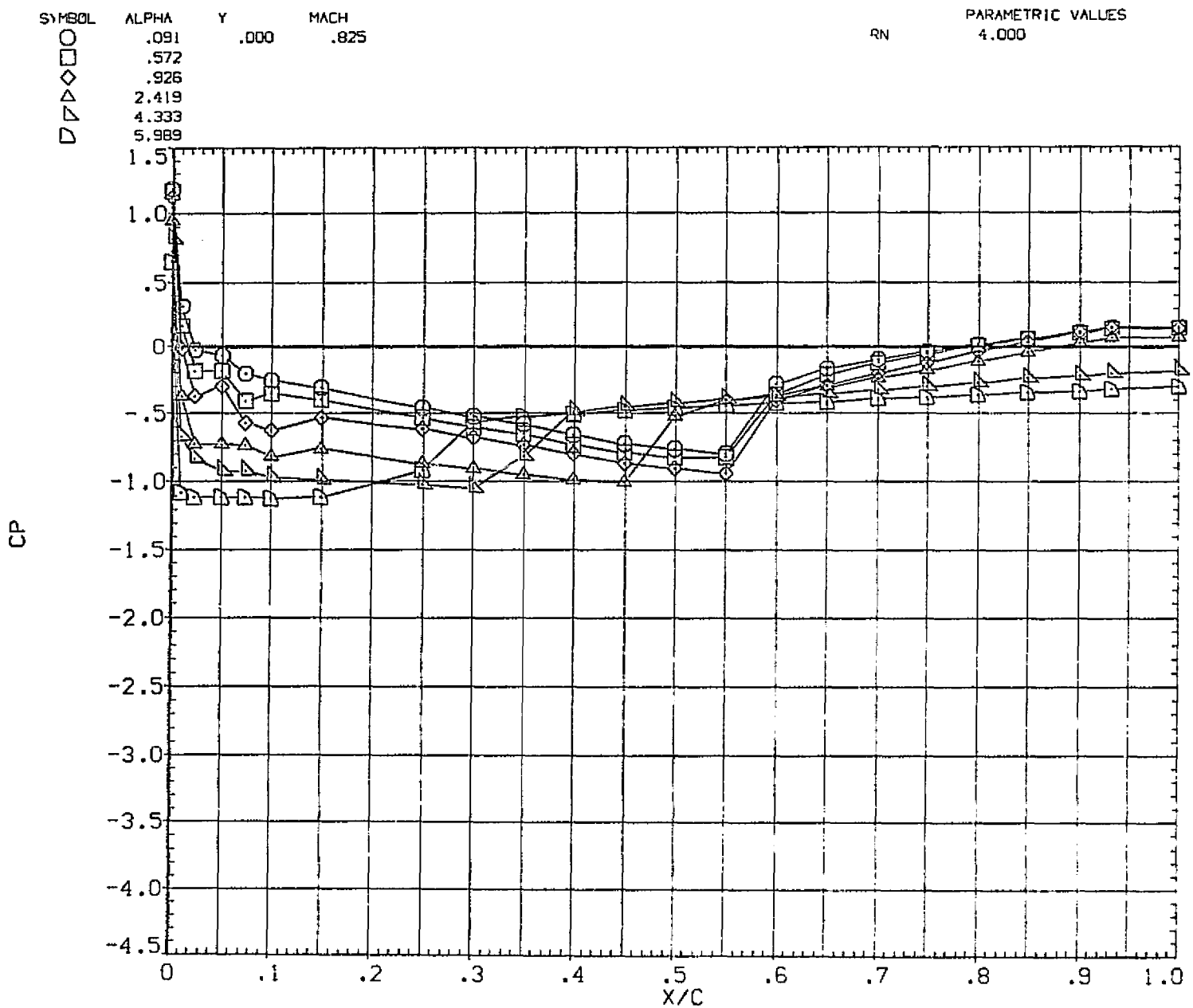


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

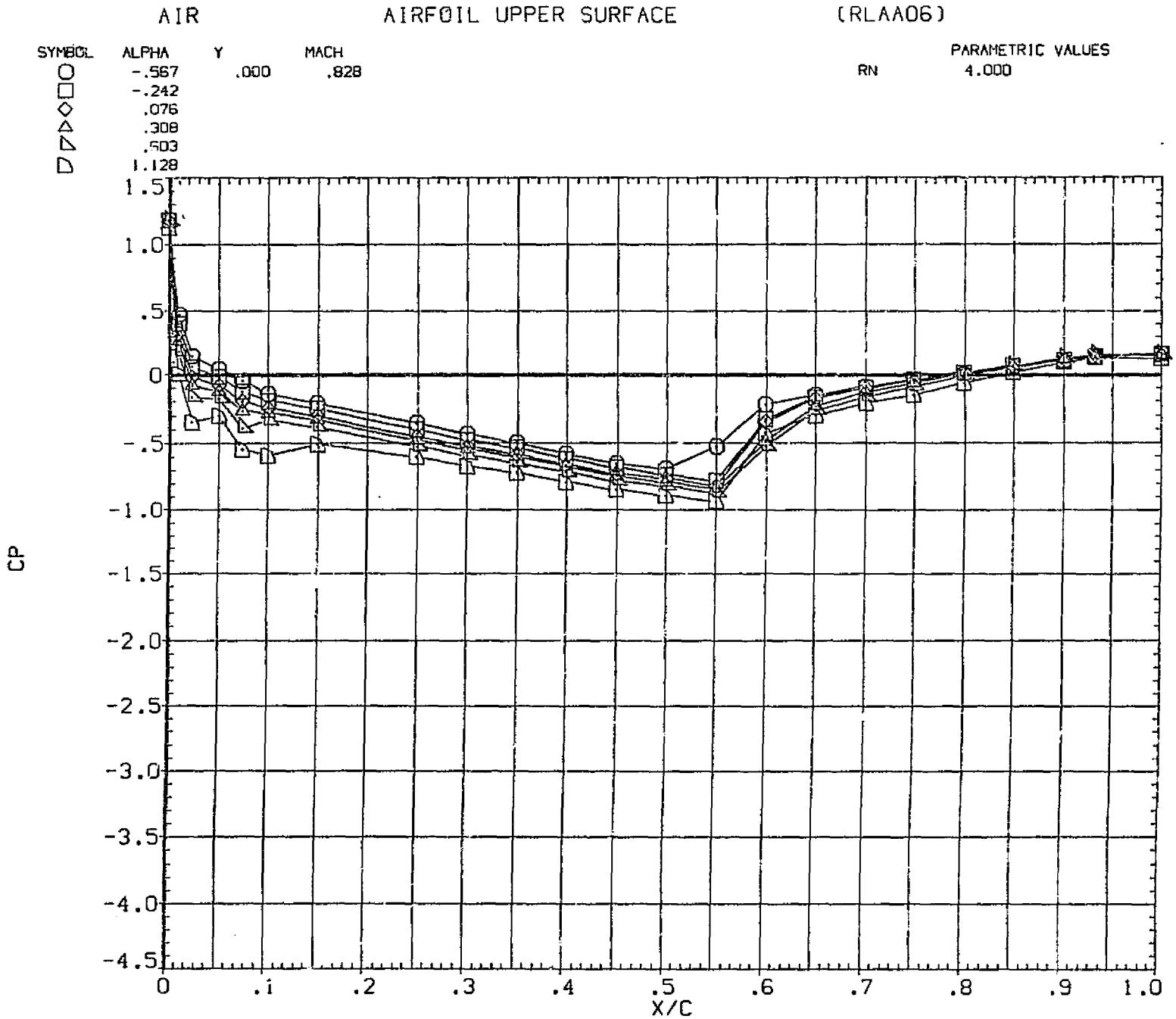


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

SYMBOL	ALPHA	Y	MACH
○	2.615	.000	.828
□	4.377		
◇	6.100		

PARAMETRIC VALUES
RN 4.000

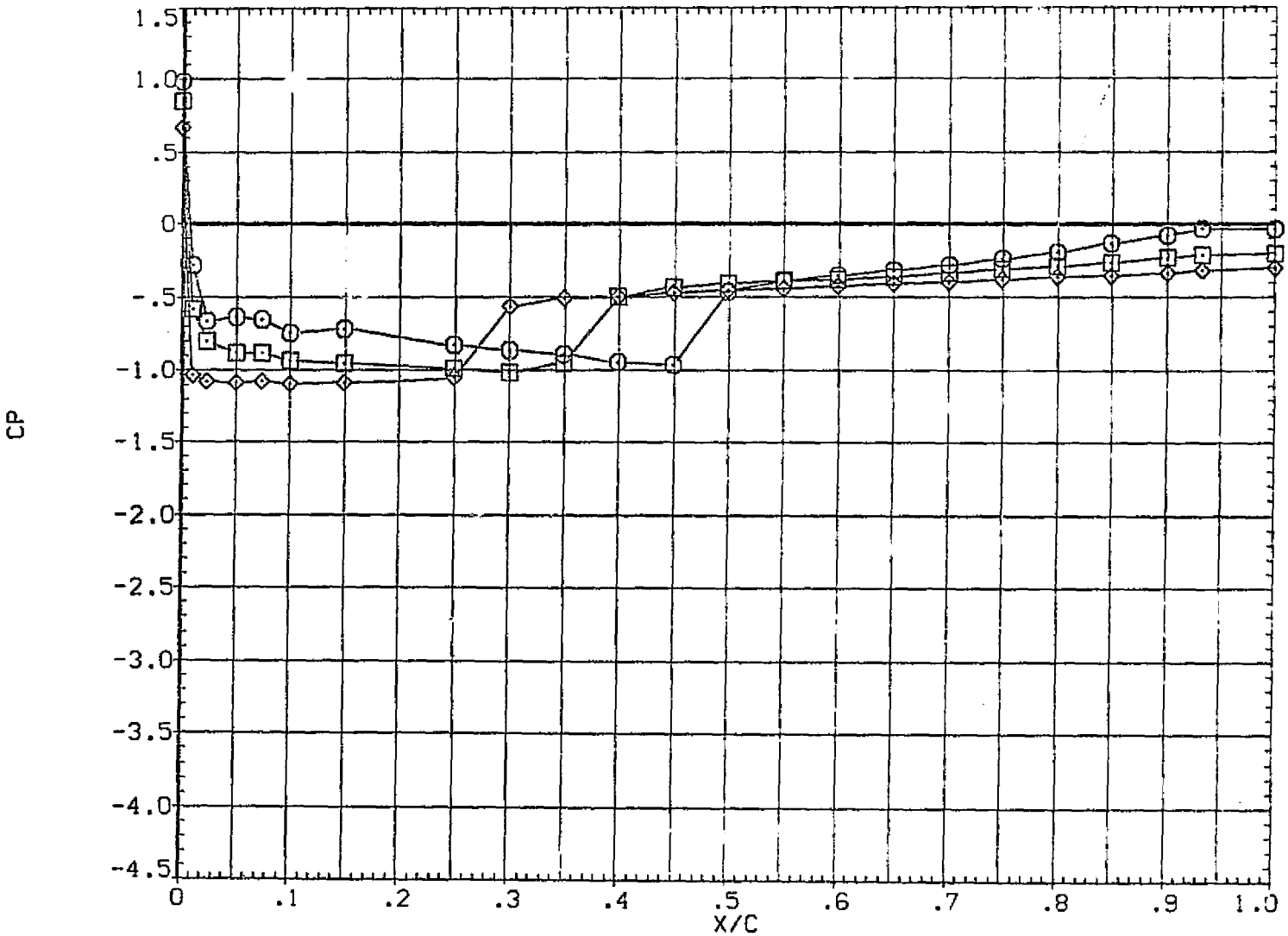


FIG. 3 BASIC DATA. PRESSURE DISTRIBUTIONS IN AIR

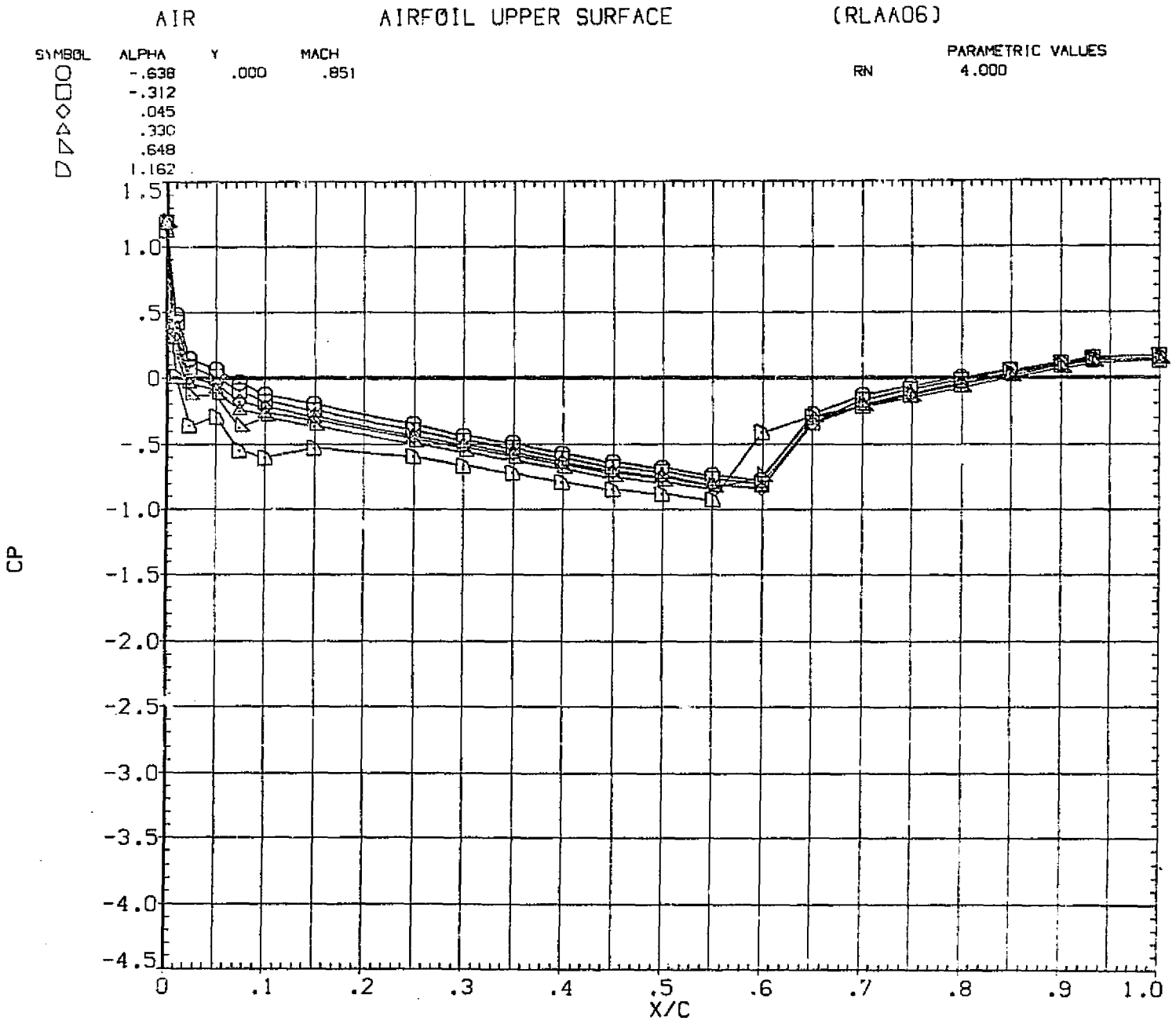


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

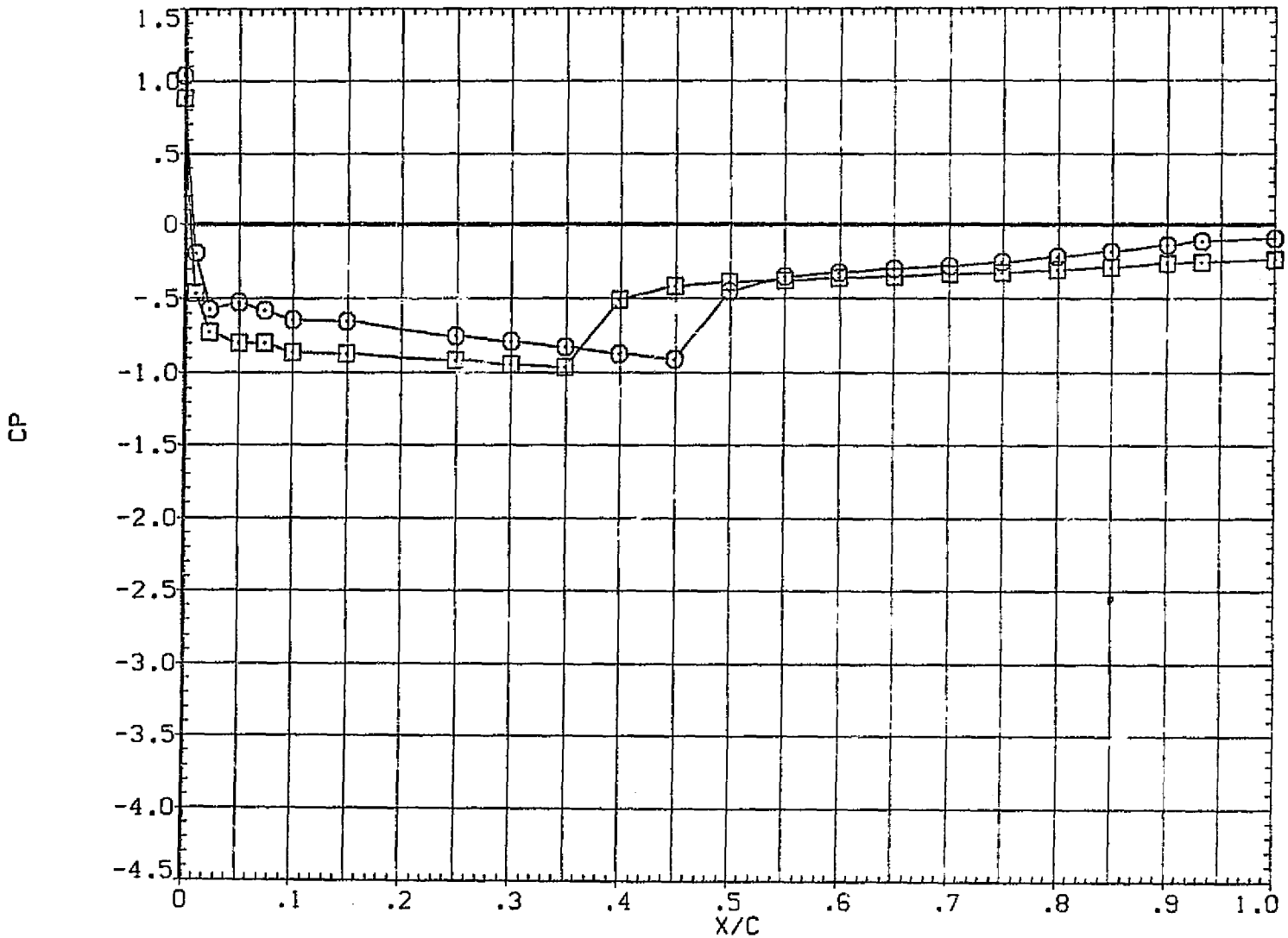


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

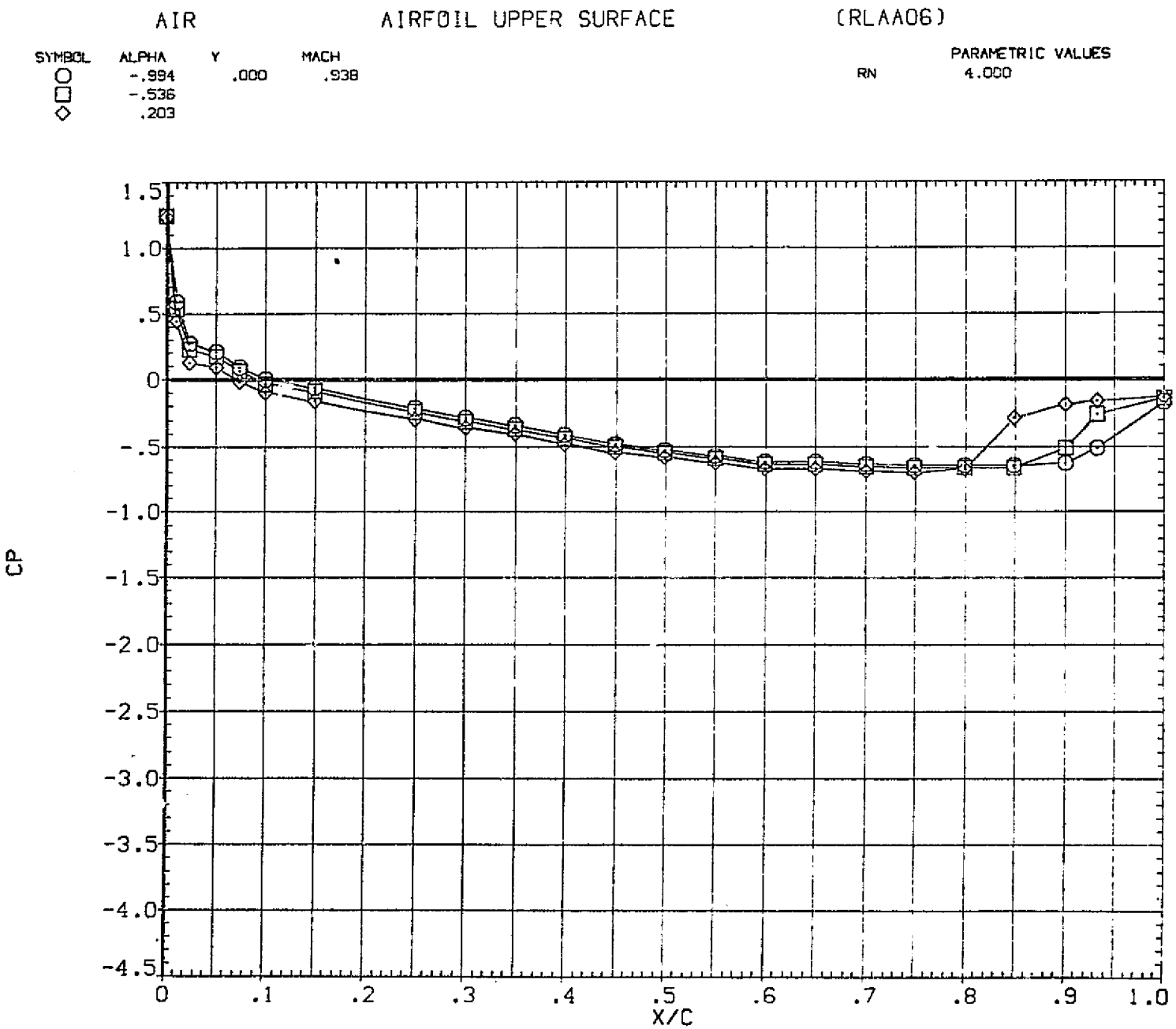


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

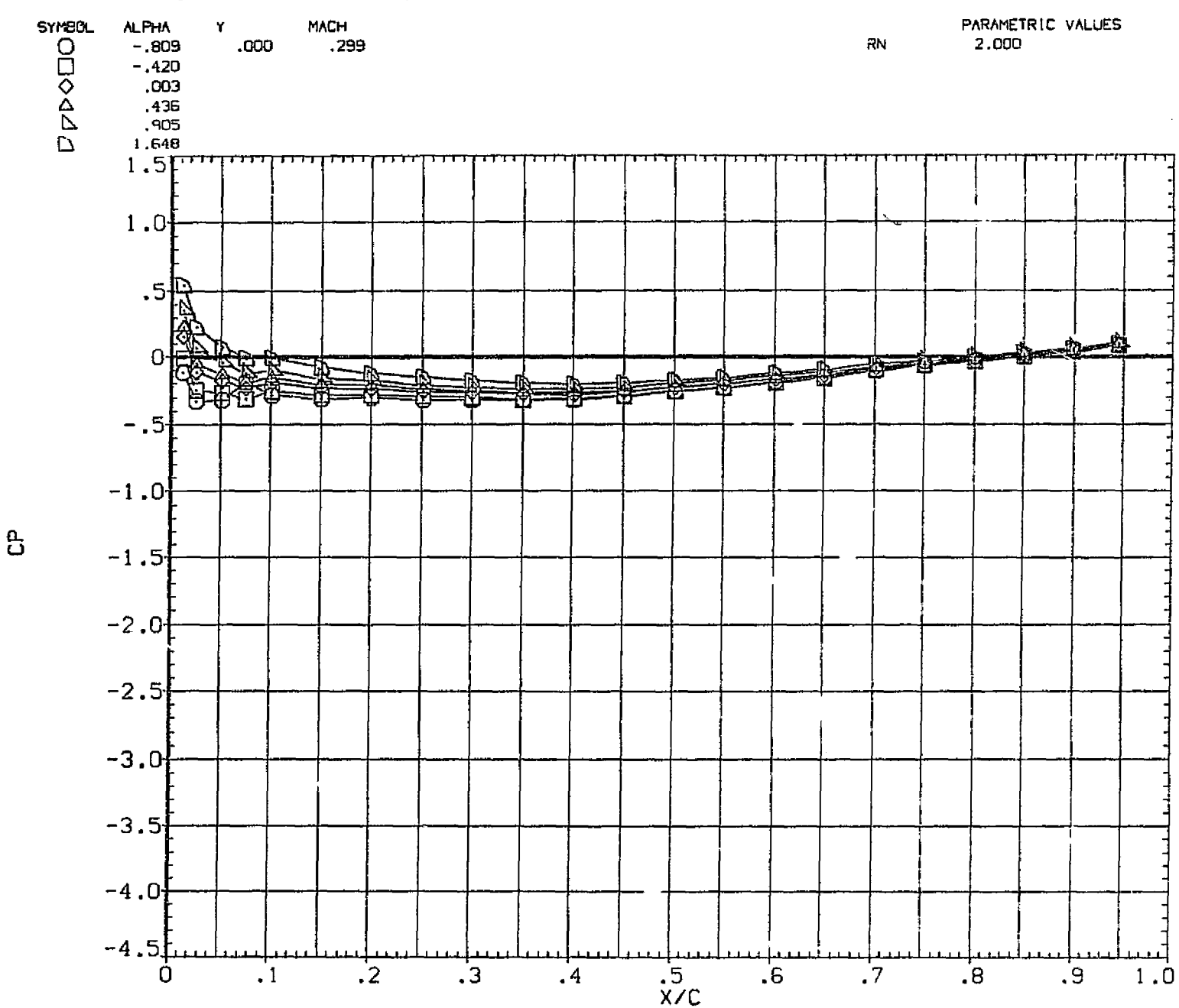


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

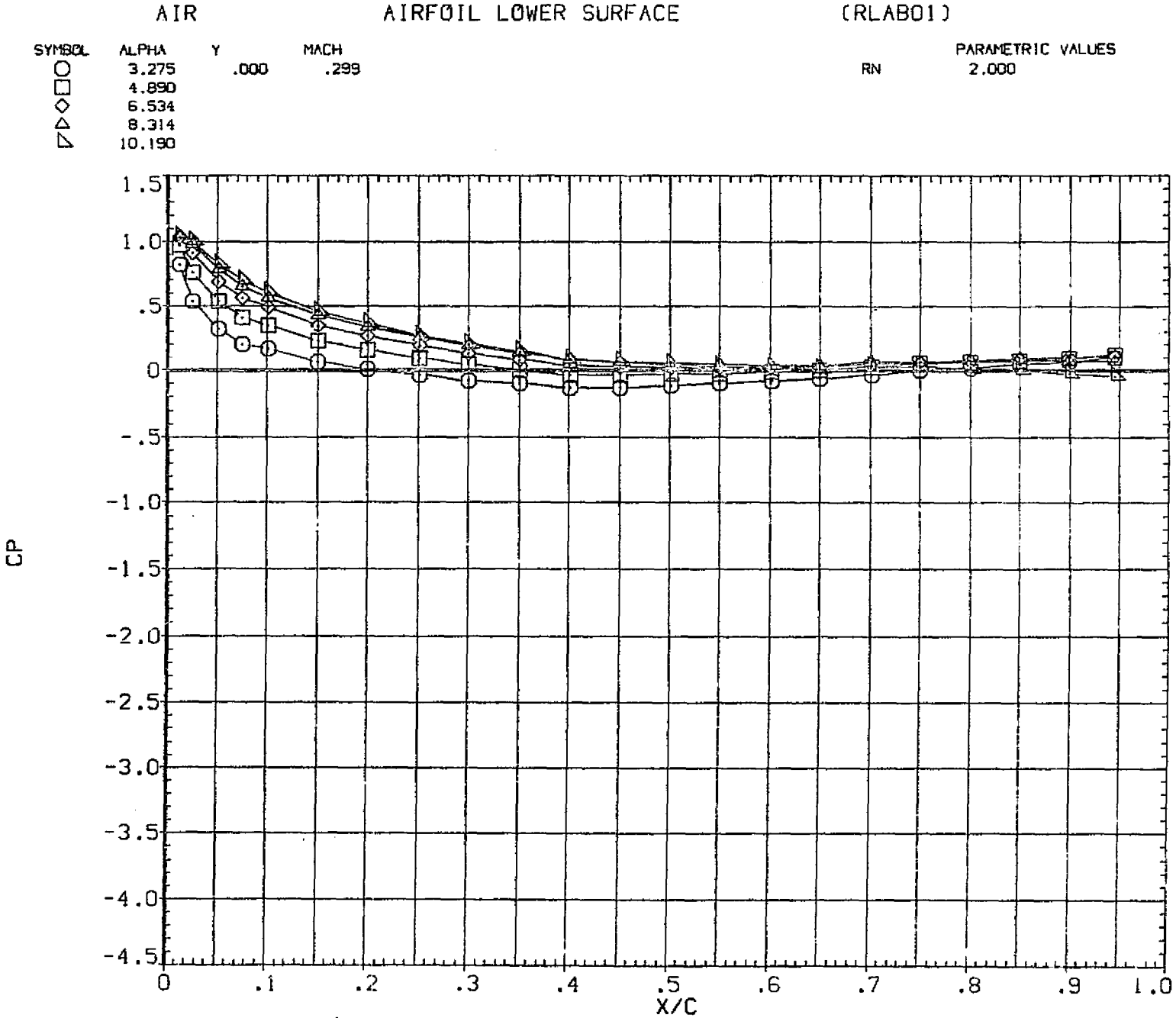


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

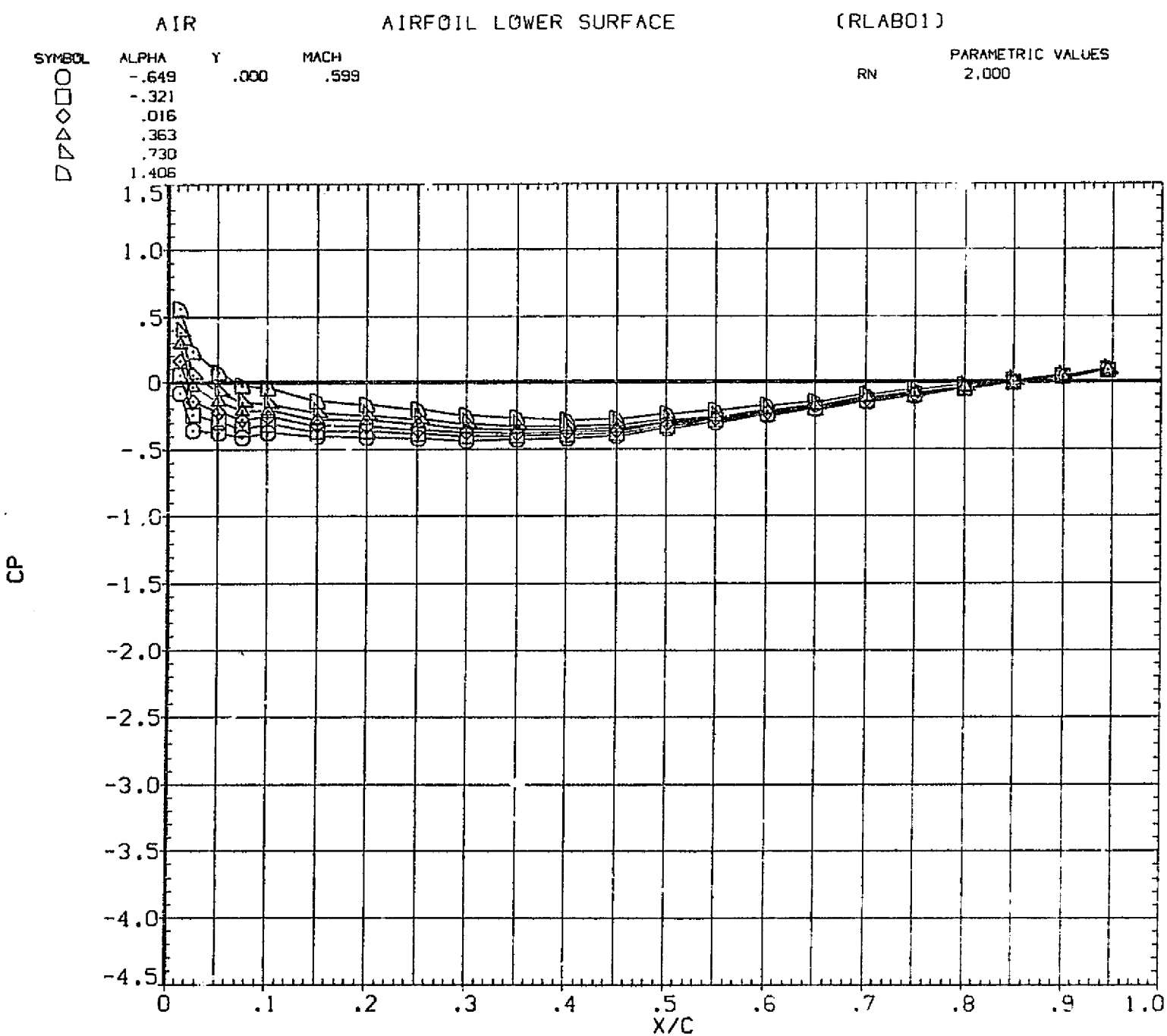


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

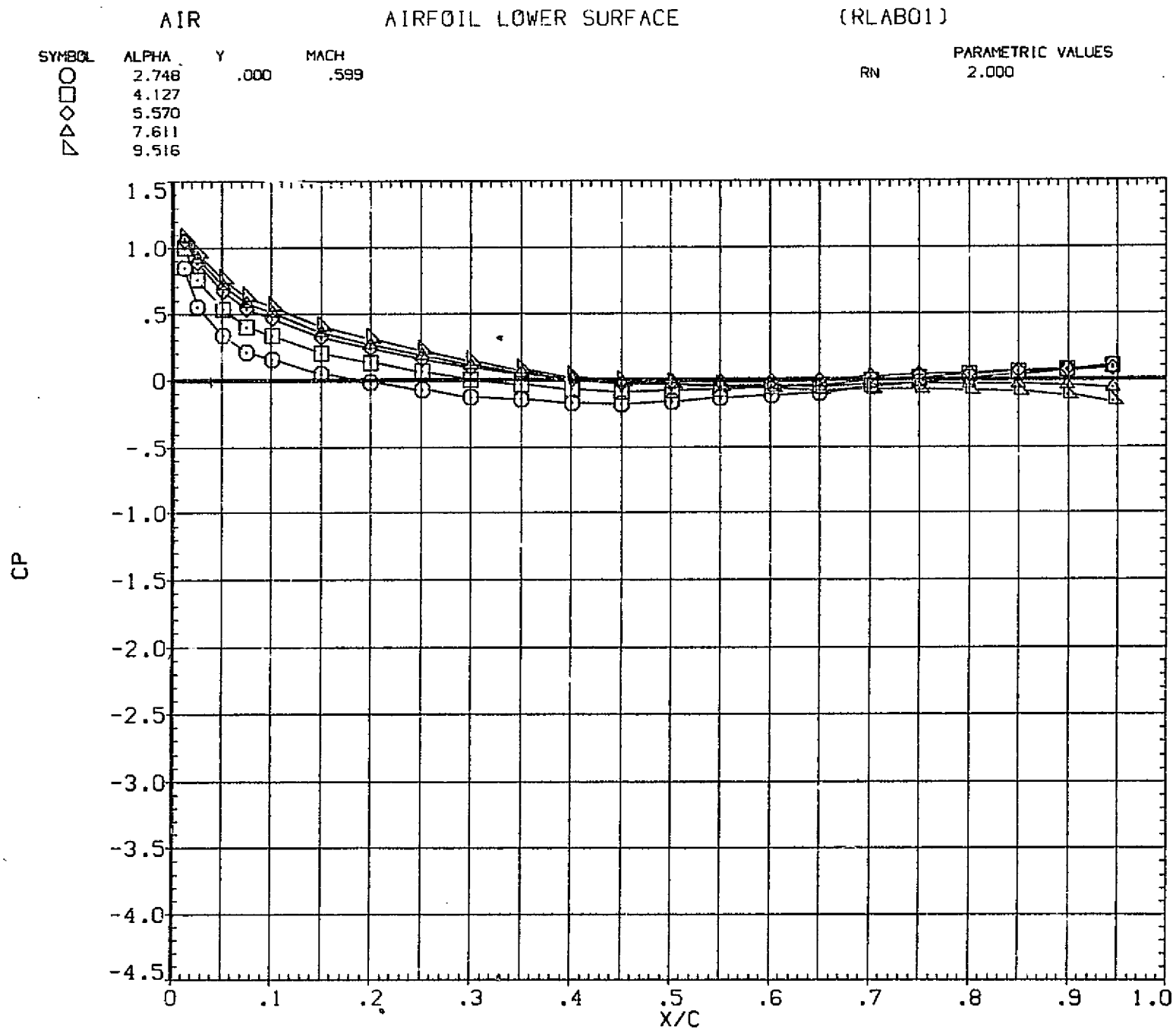


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

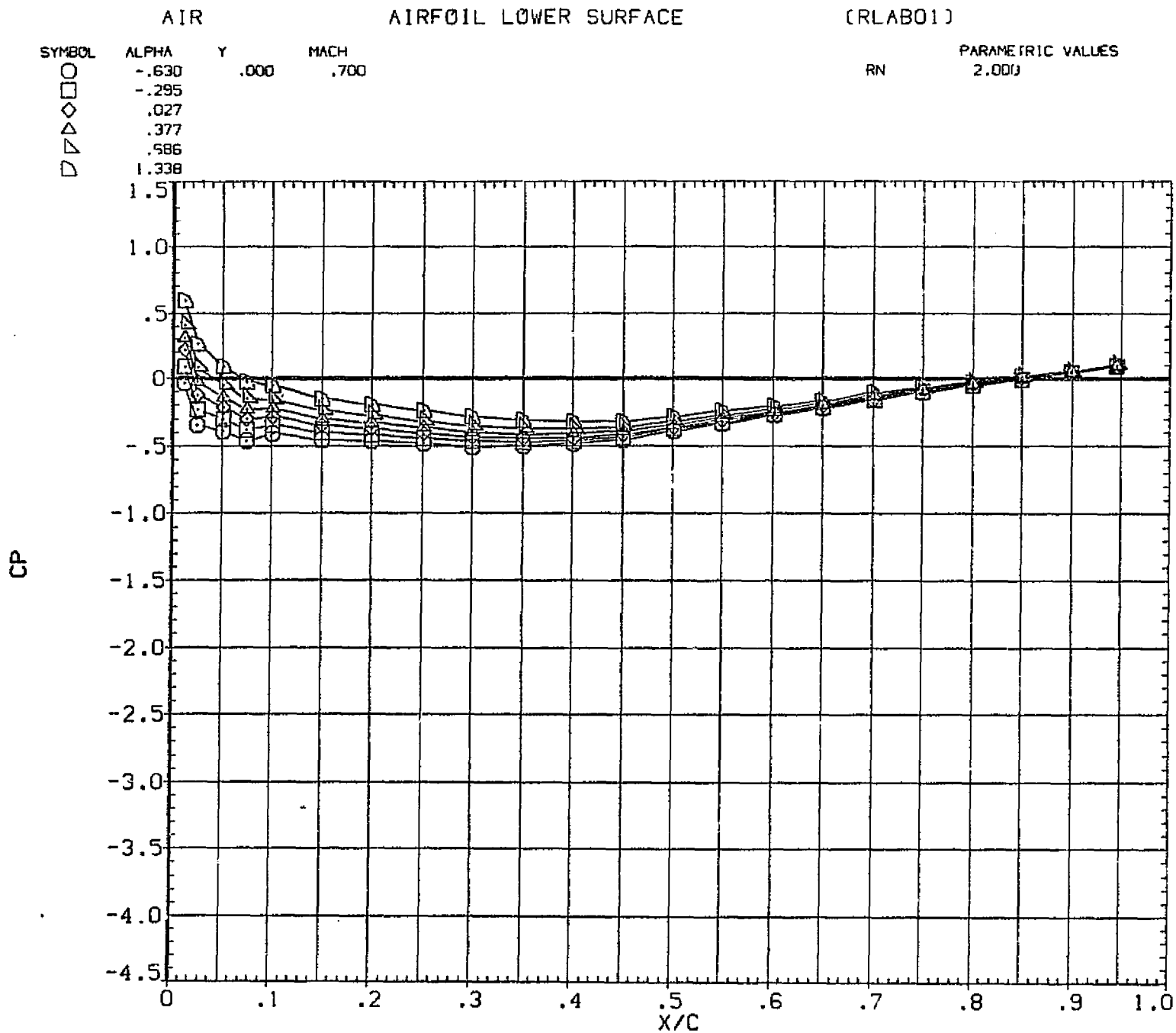


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

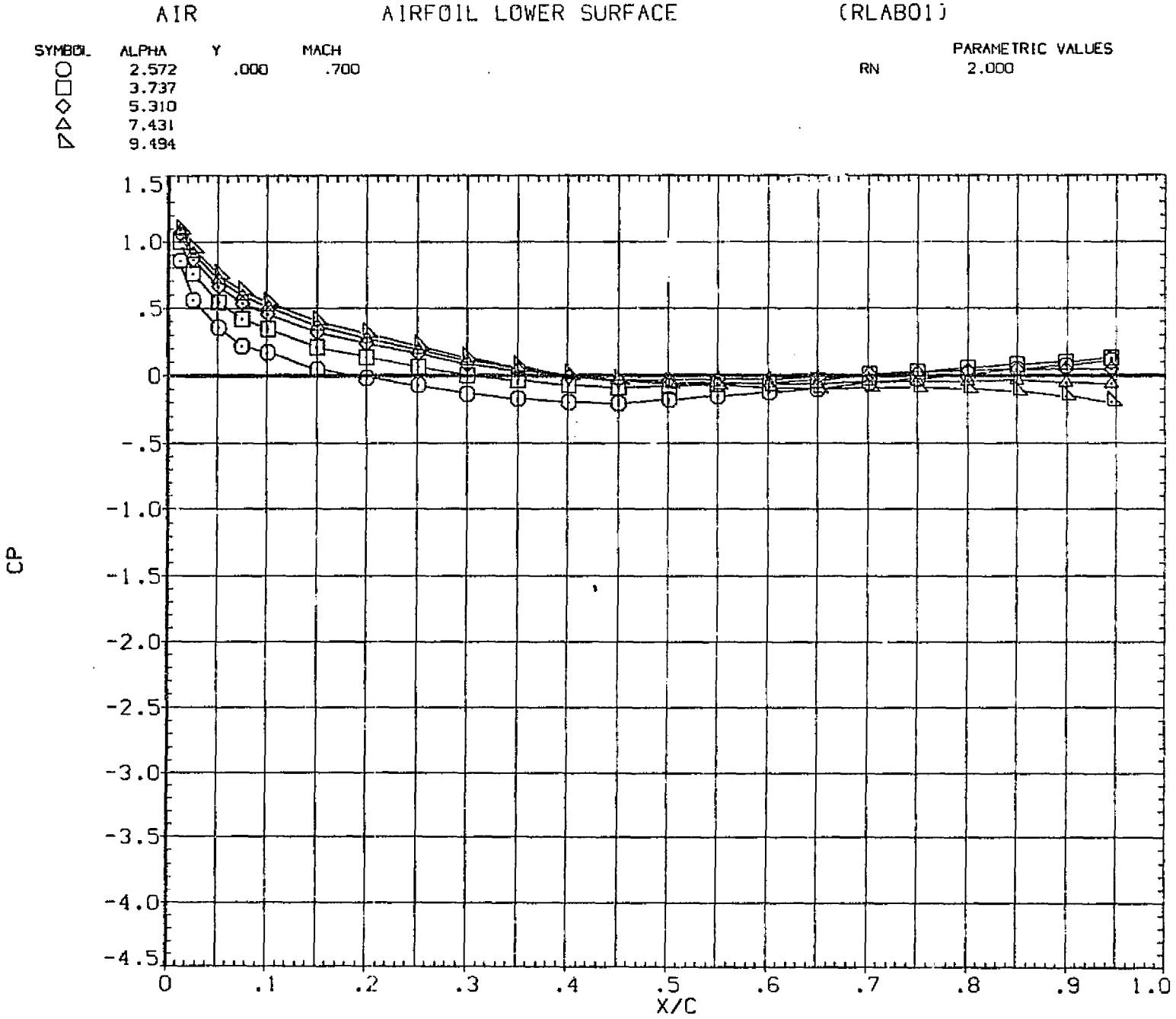


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

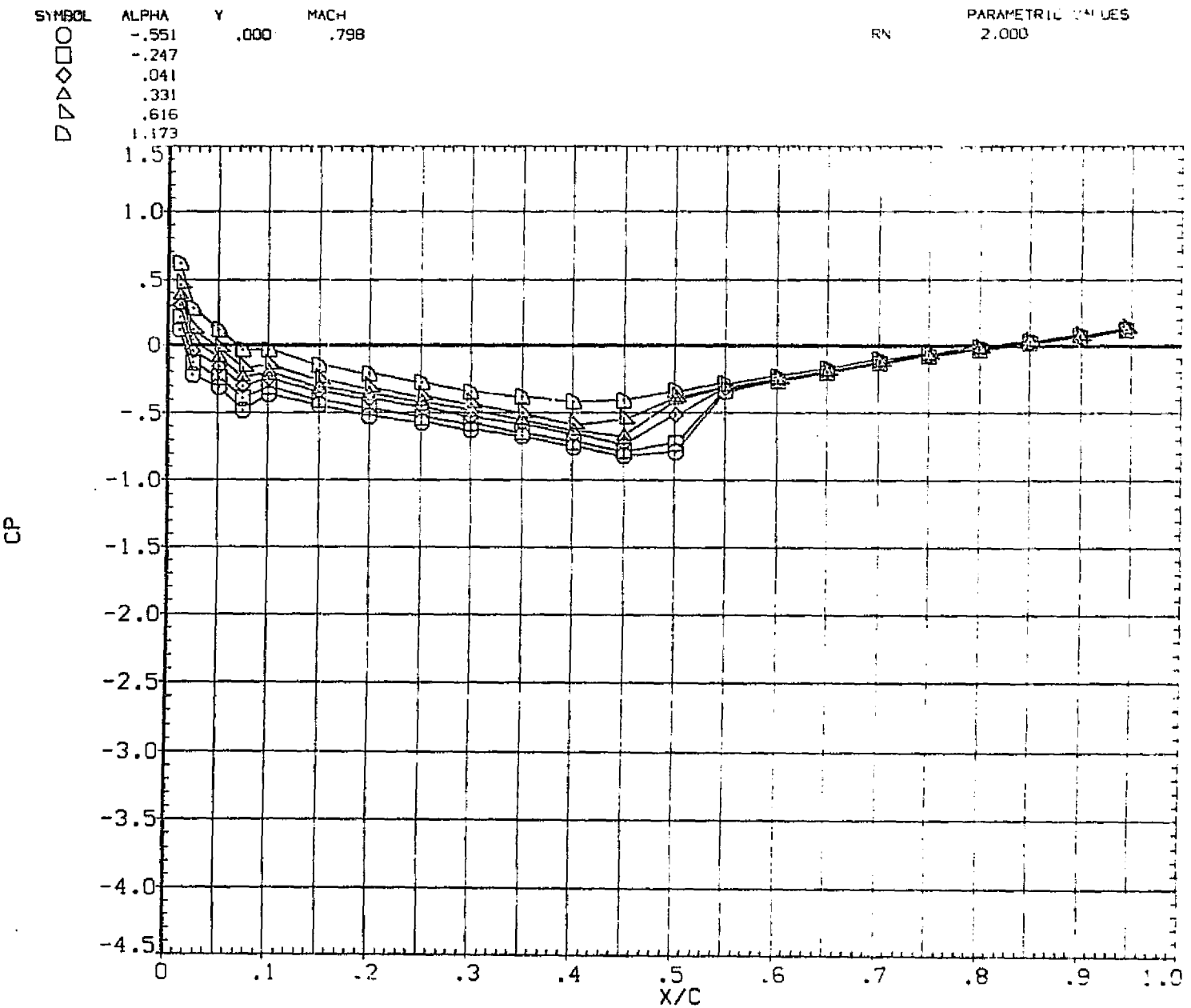


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

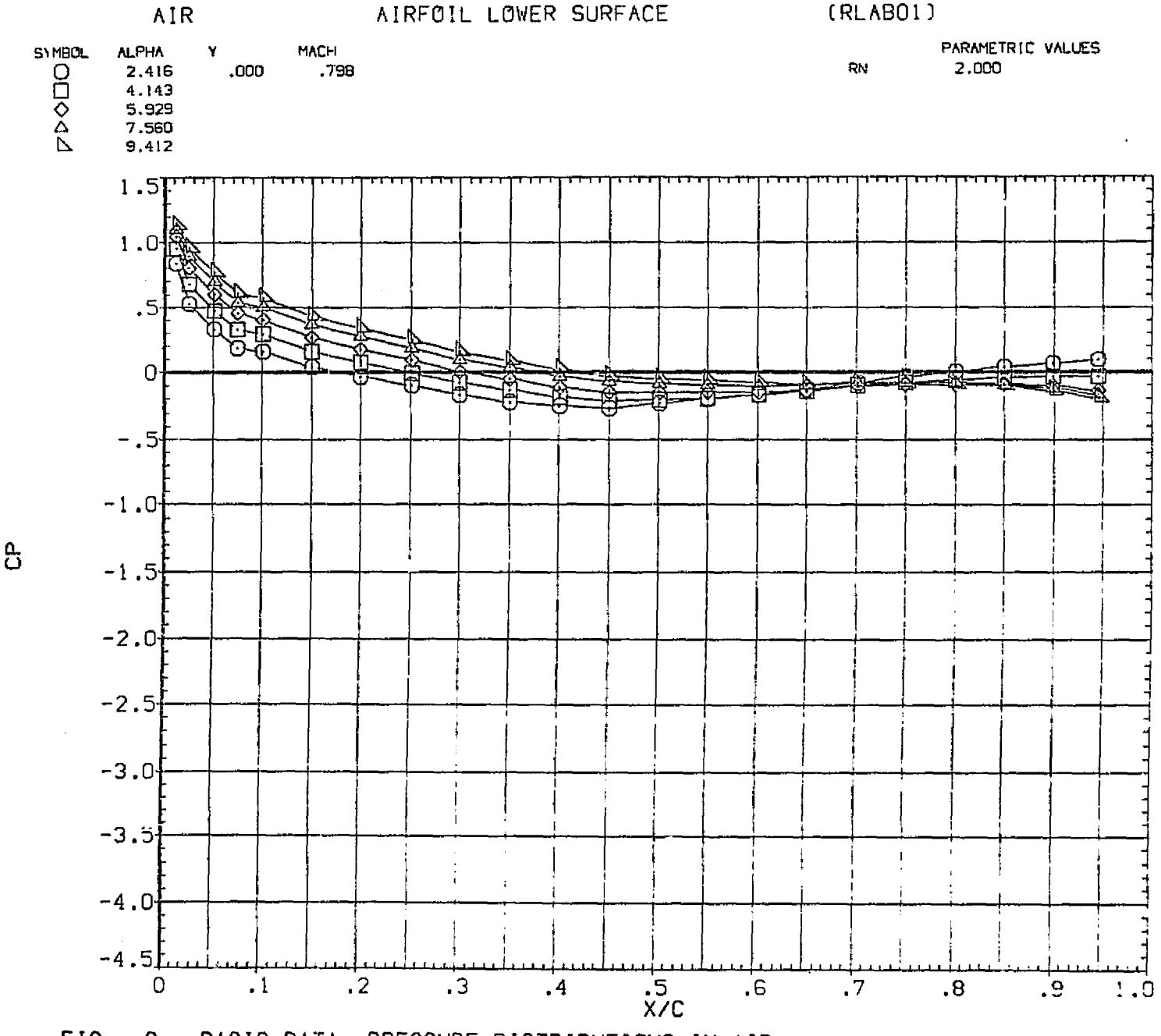


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

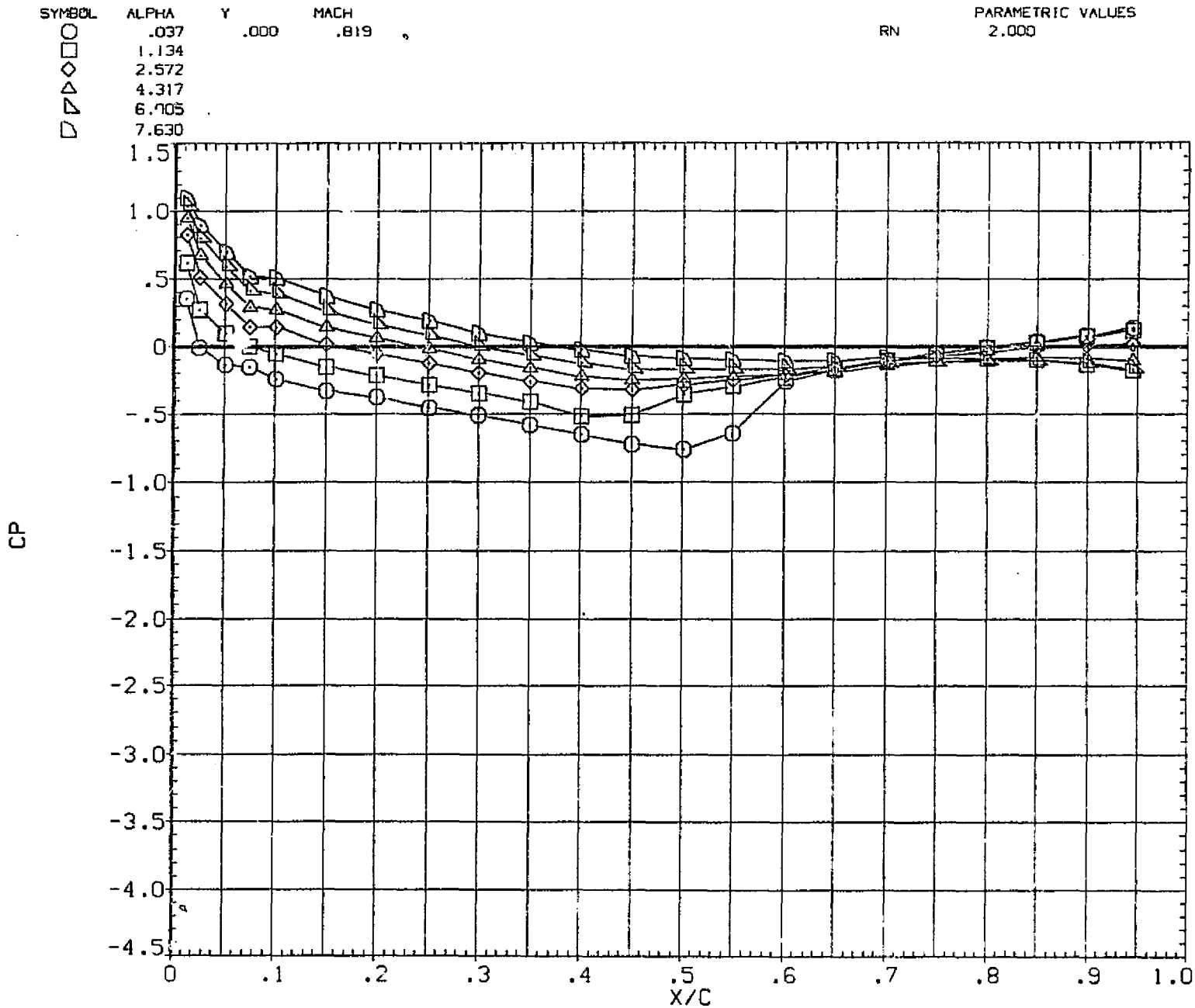


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL LOWER SURFACE (RLAB01)

SYMBOL	ALPHA	Y	MACH
O	9.363	.000	.819

PARAMETRIC VALUES
RN 2.000

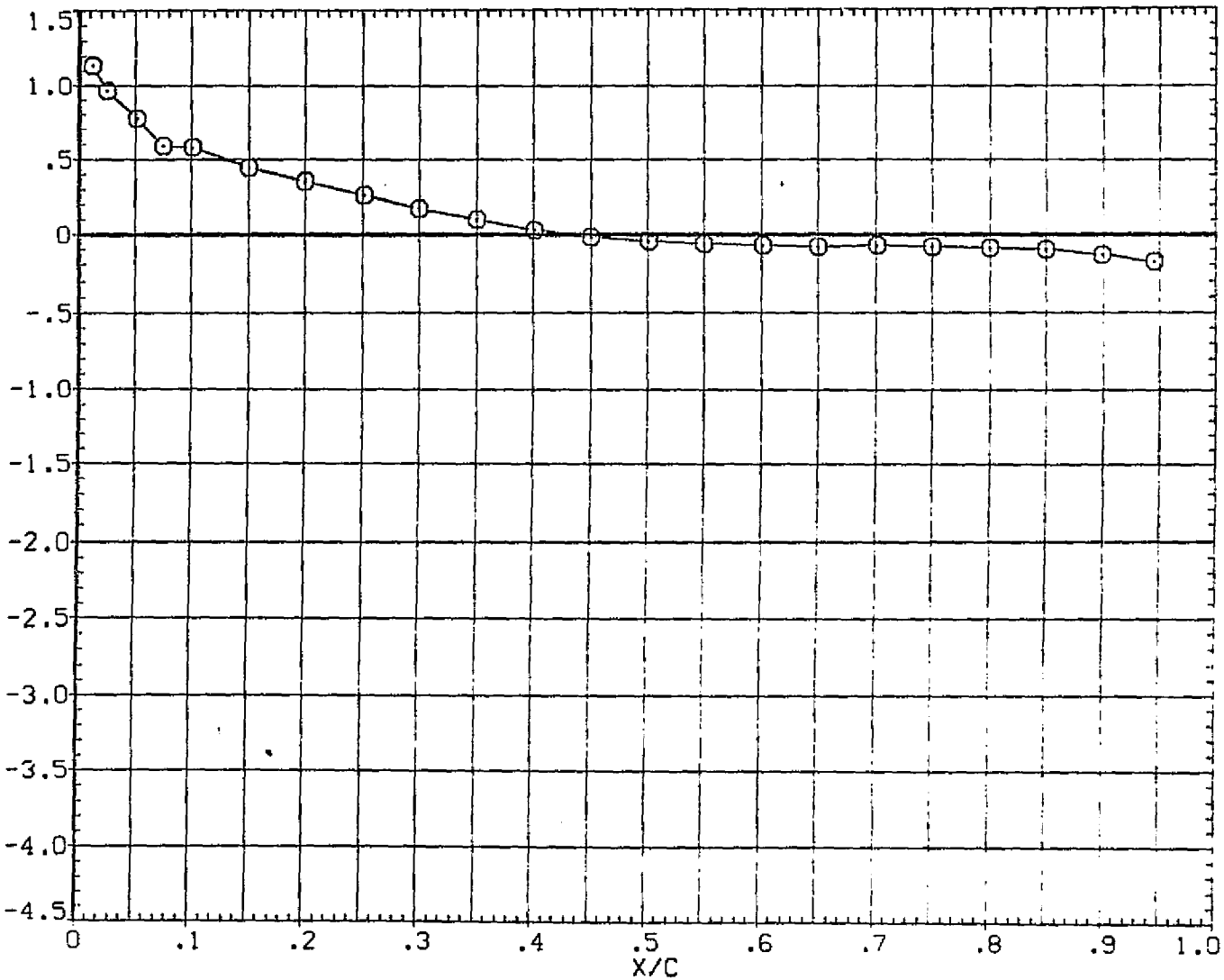


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

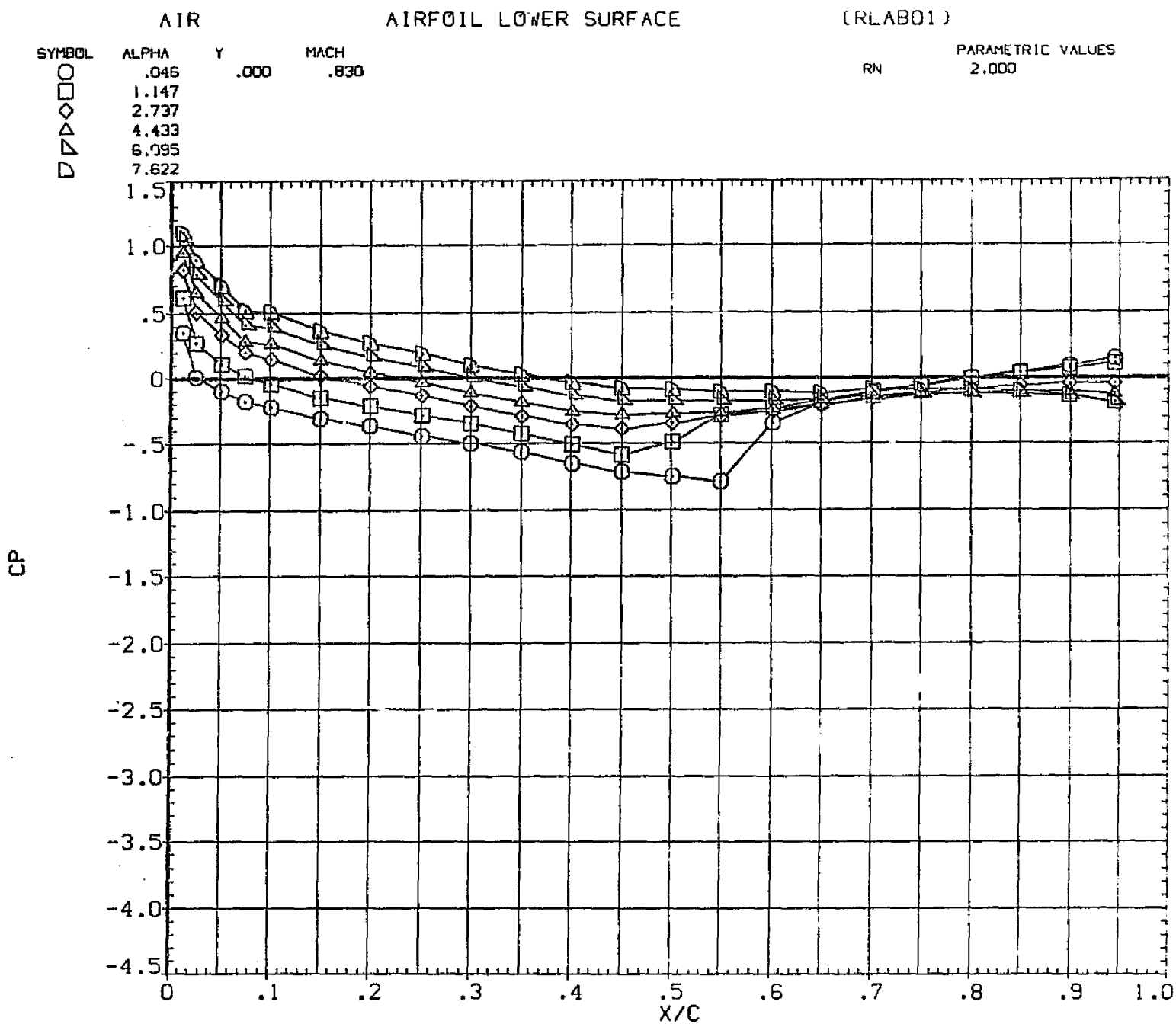


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

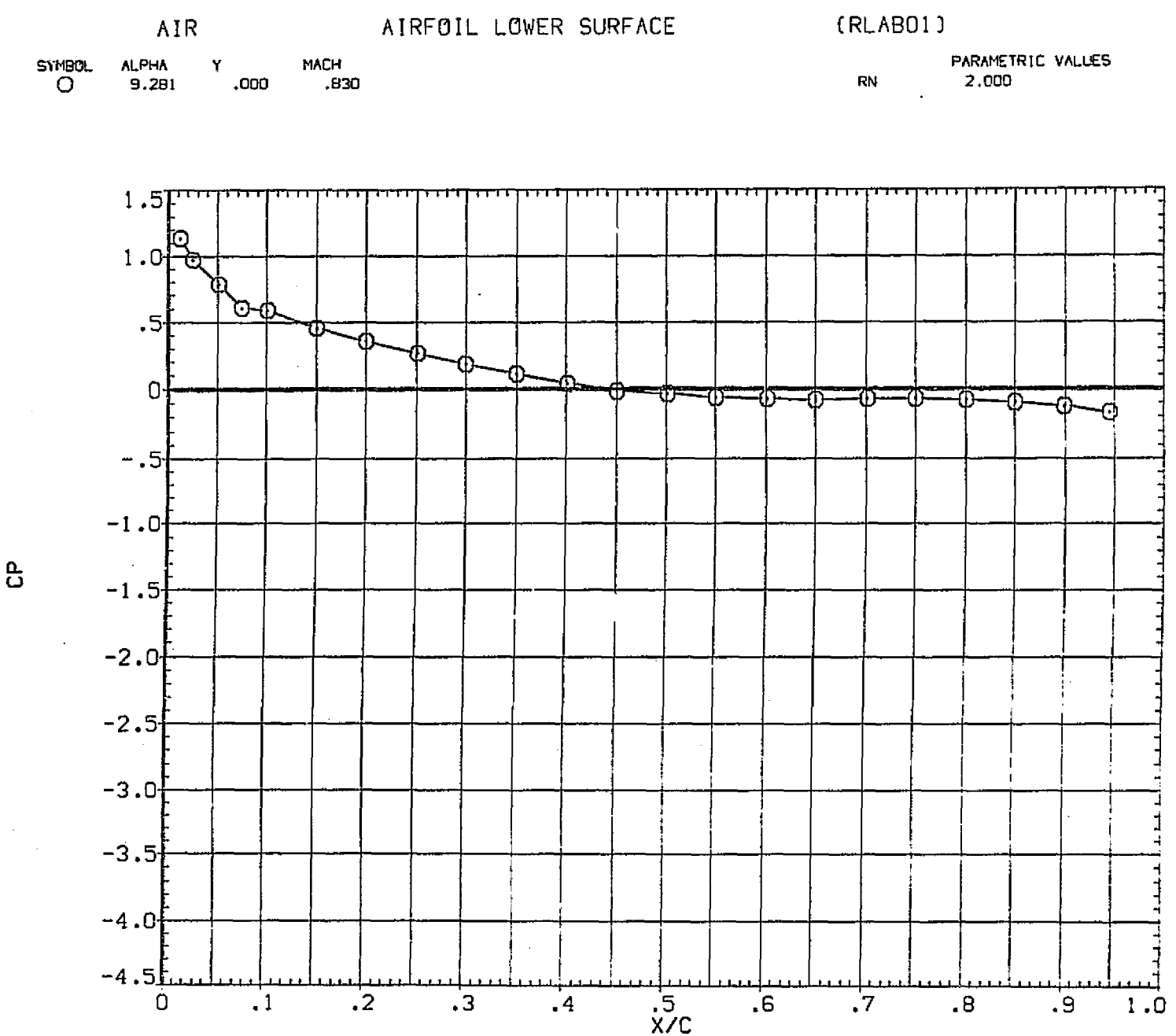


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

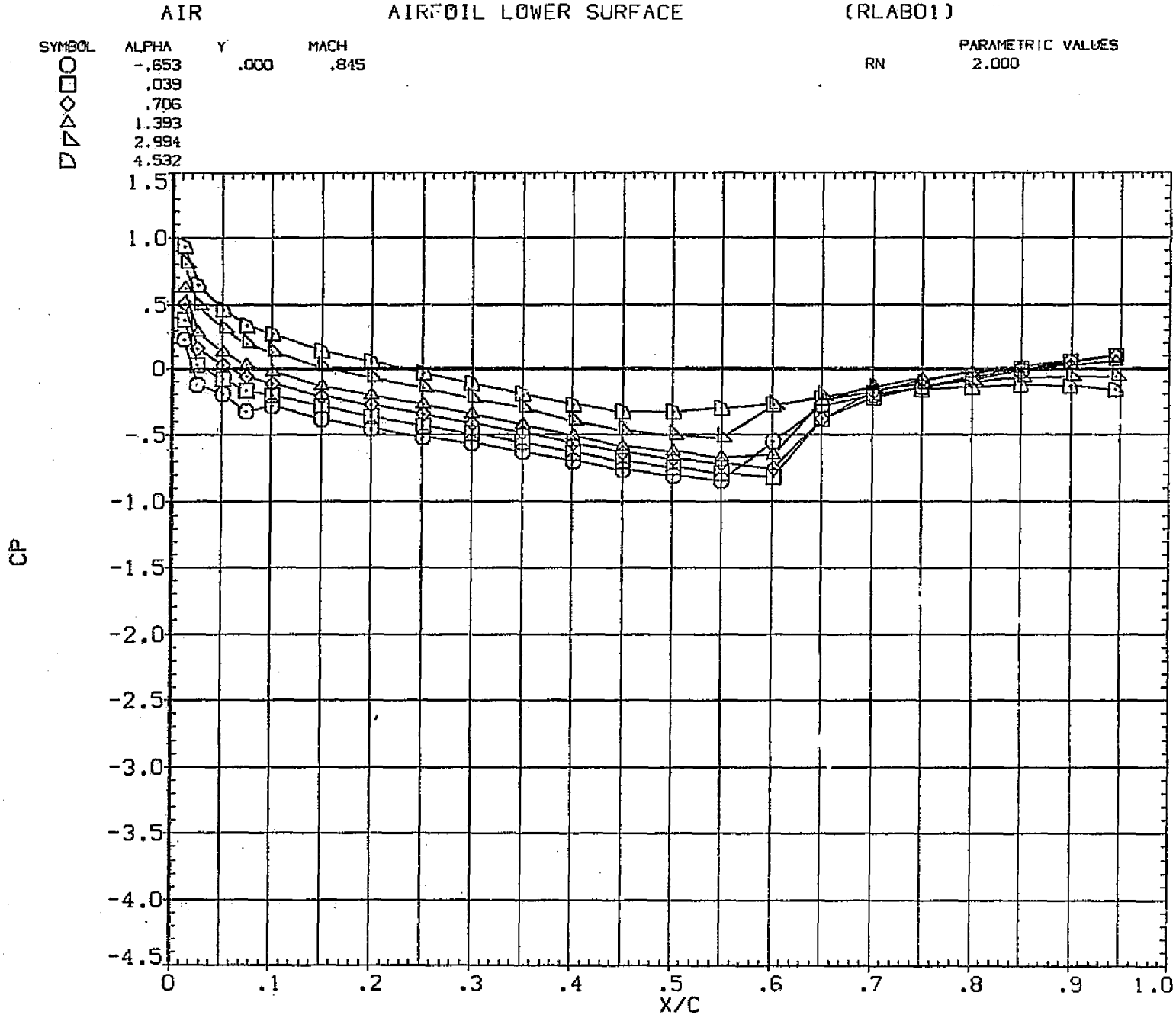


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

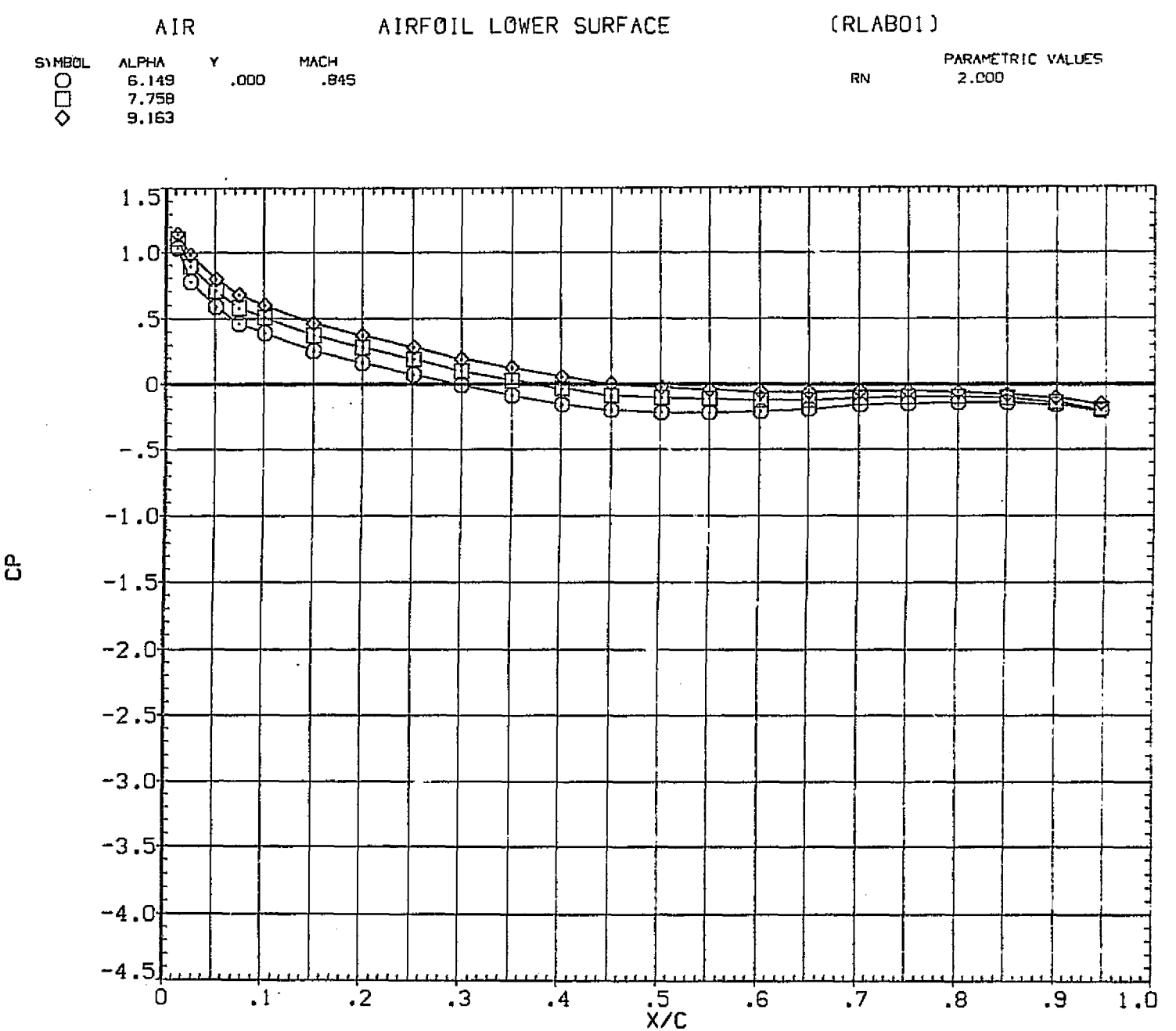


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

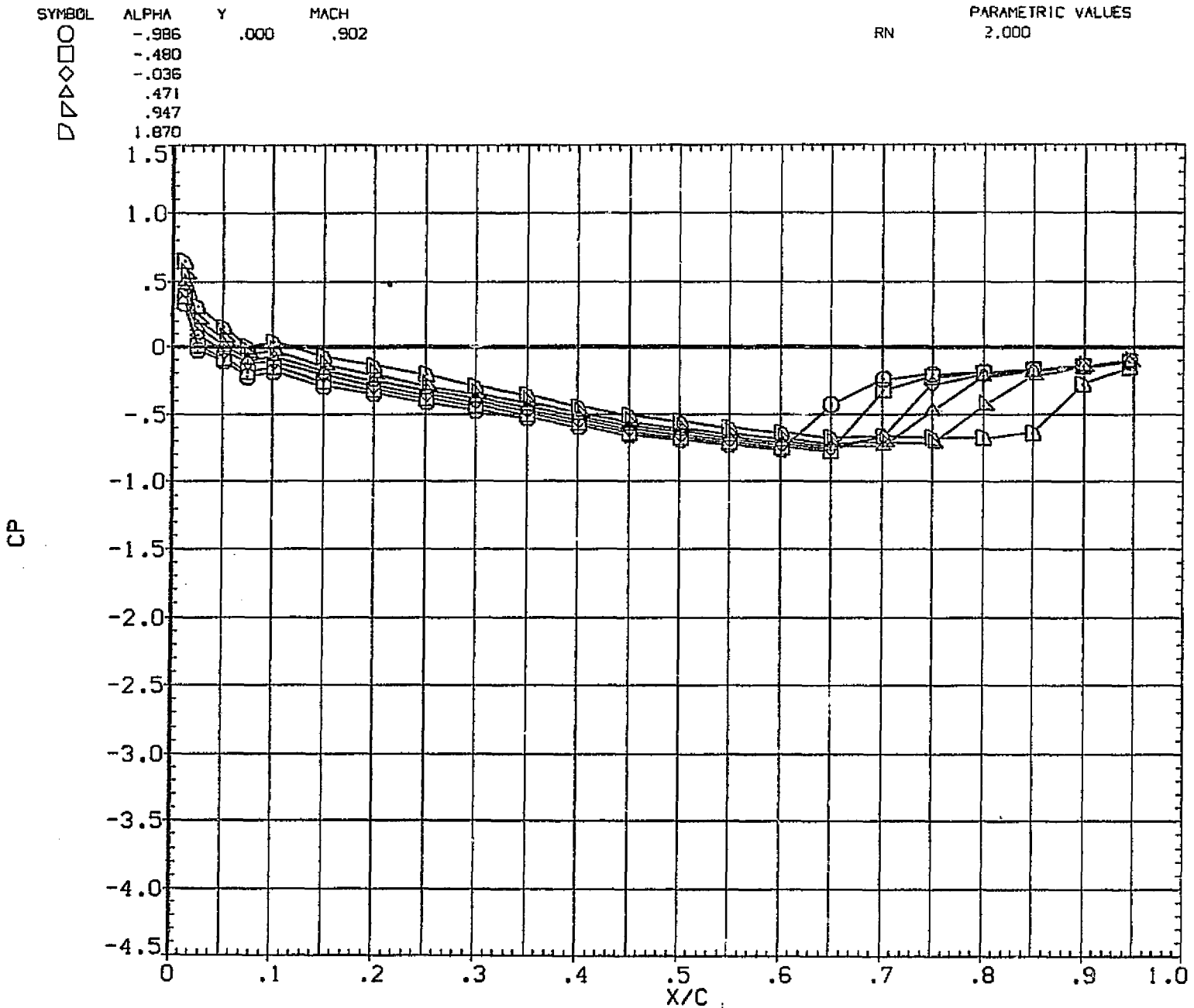


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

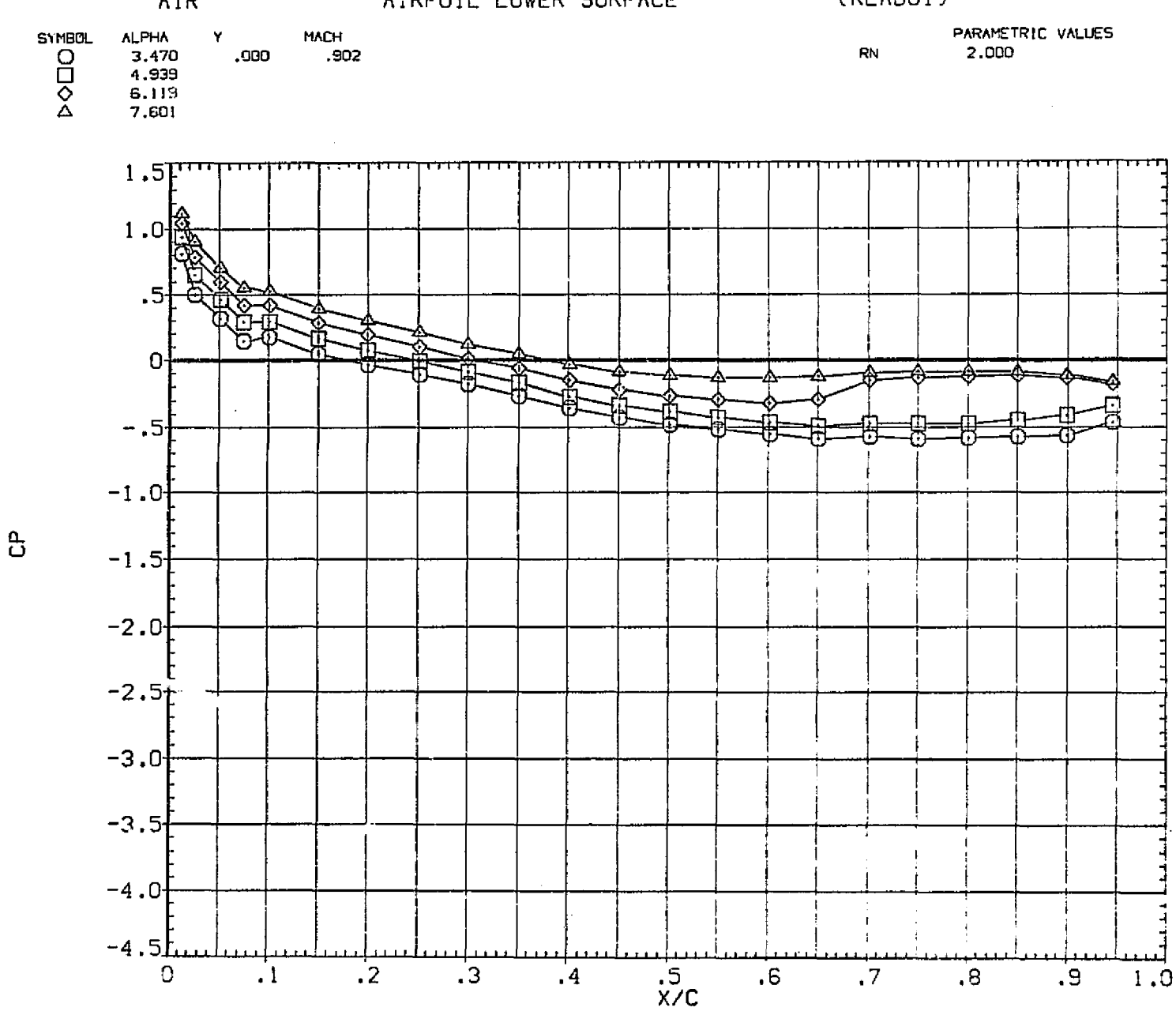


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

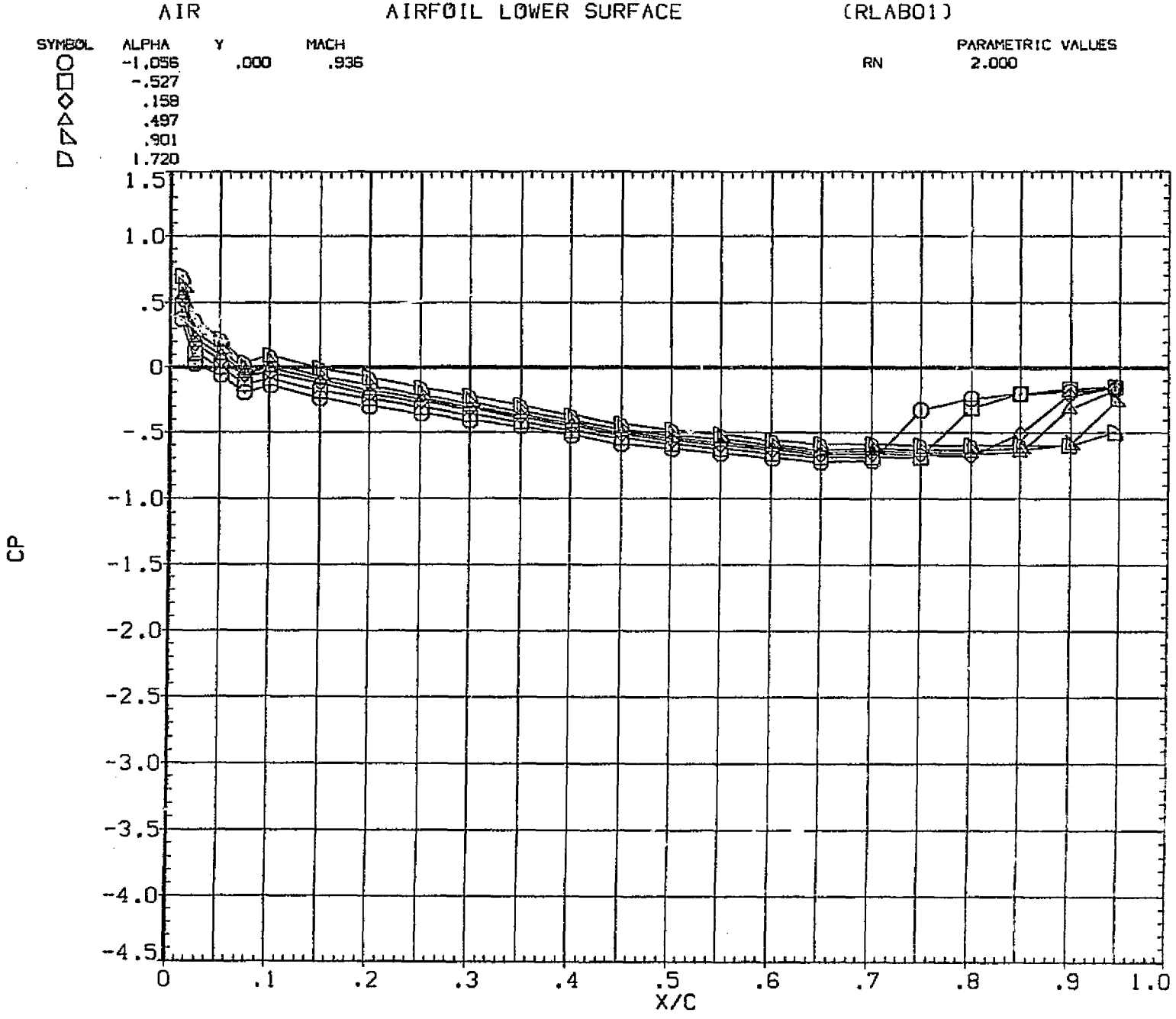


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

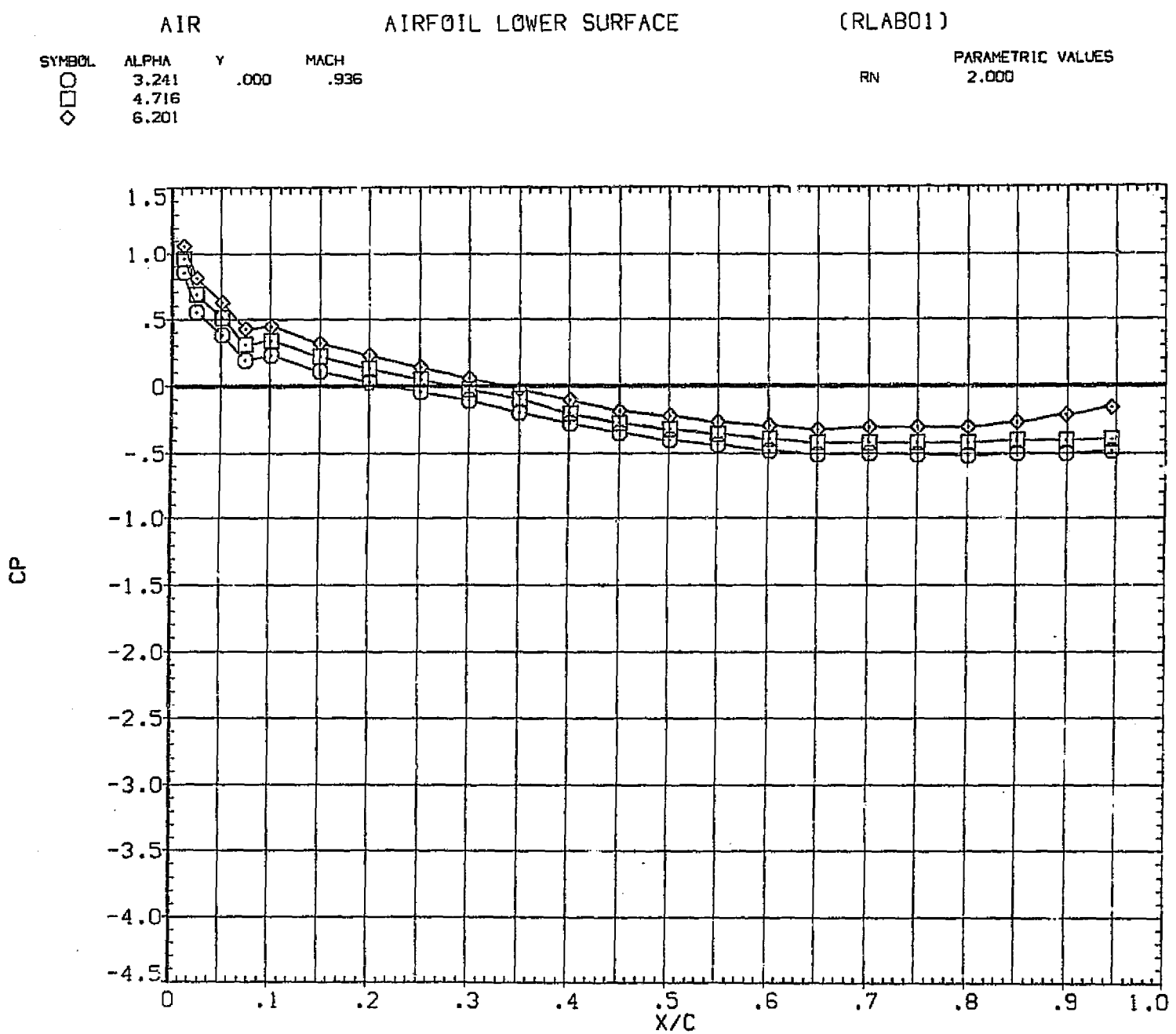


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

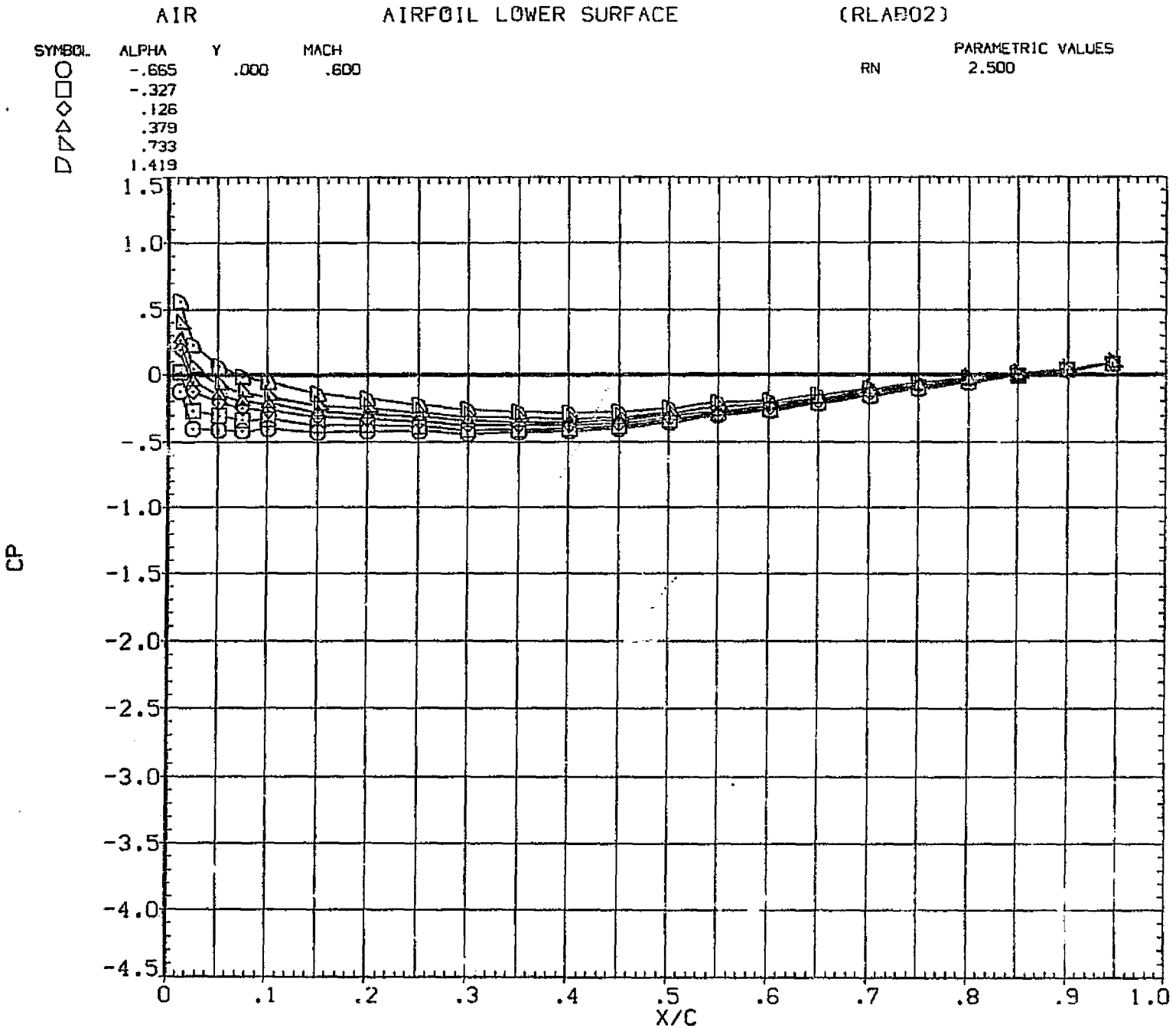


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

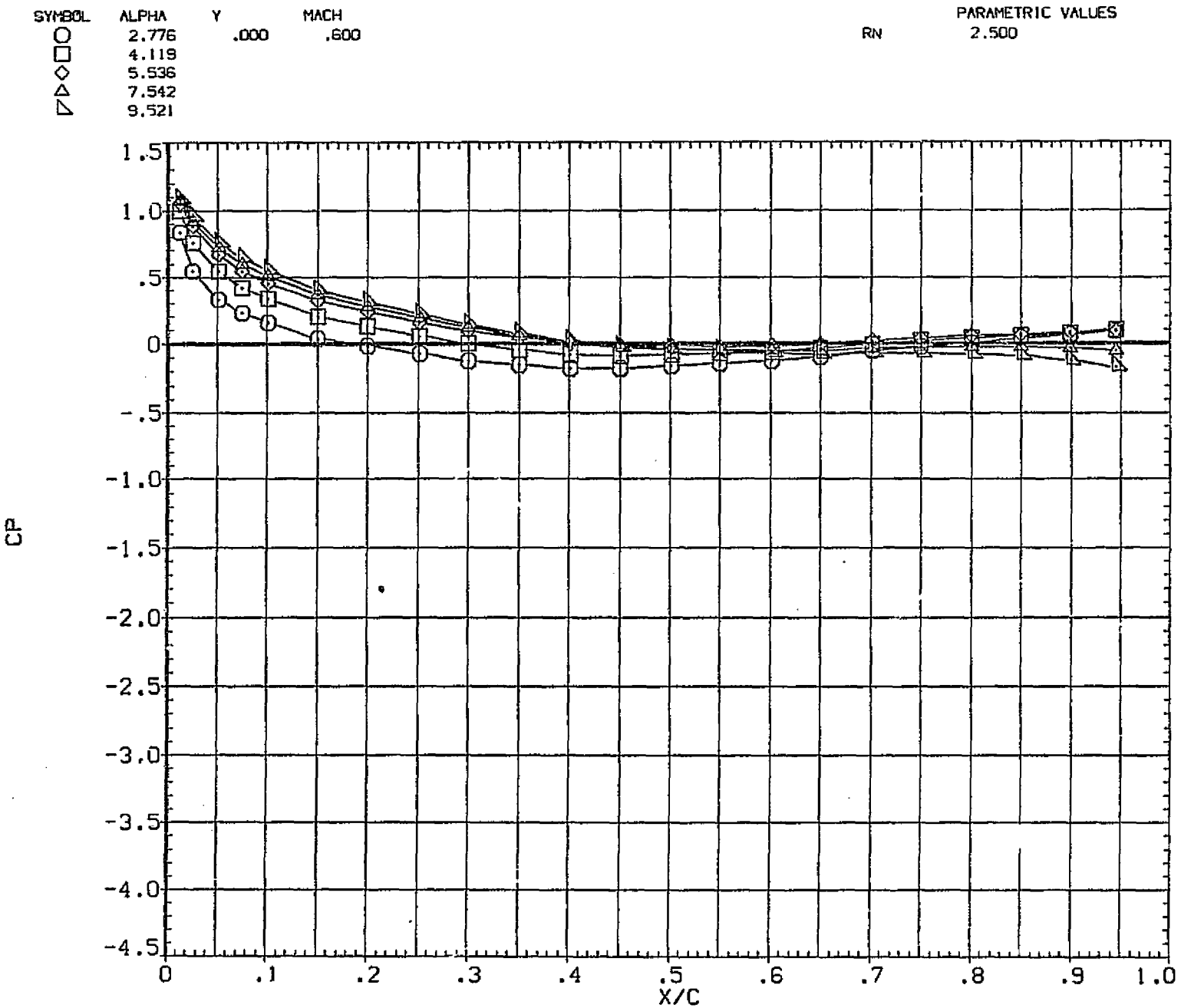


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

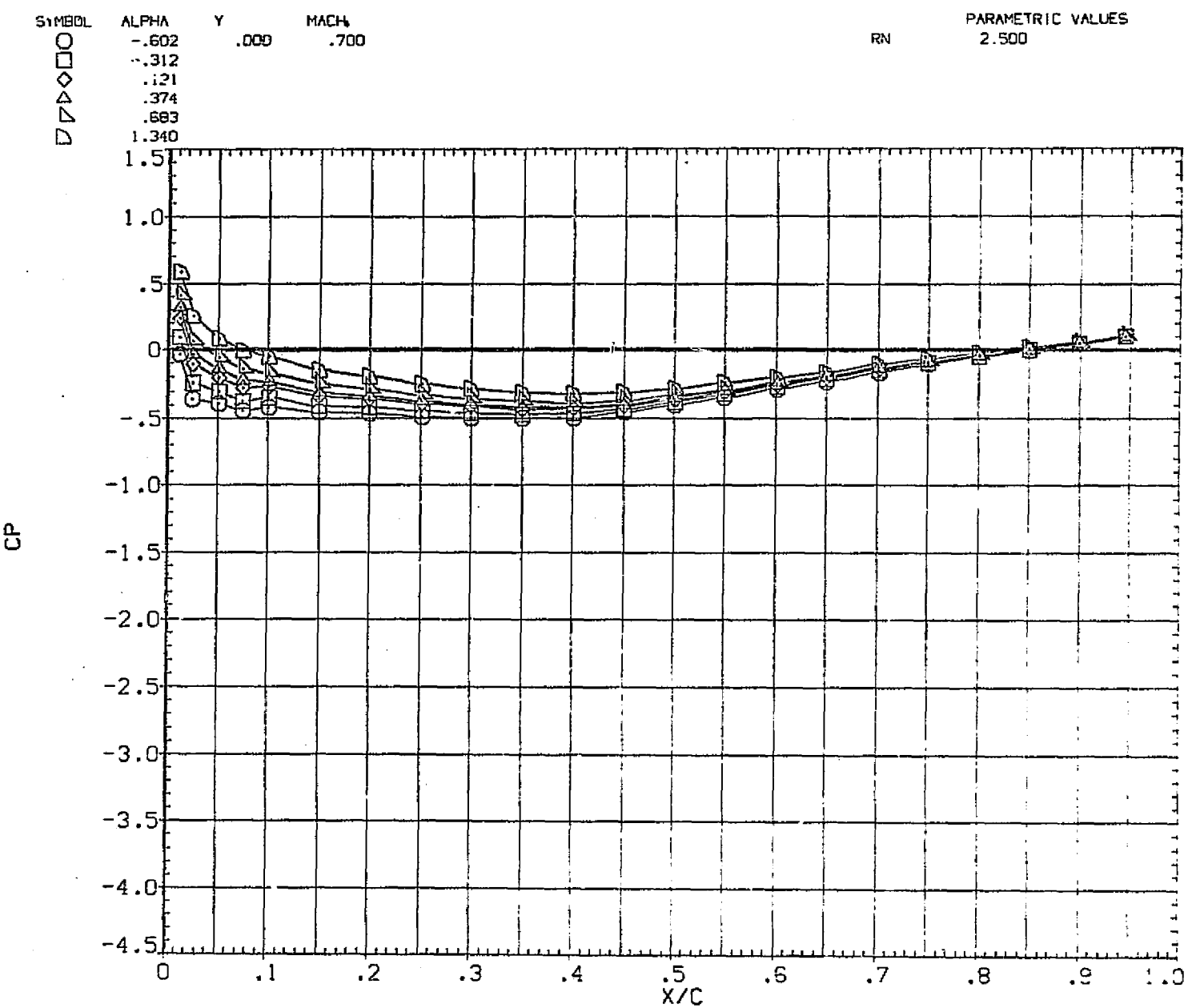


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

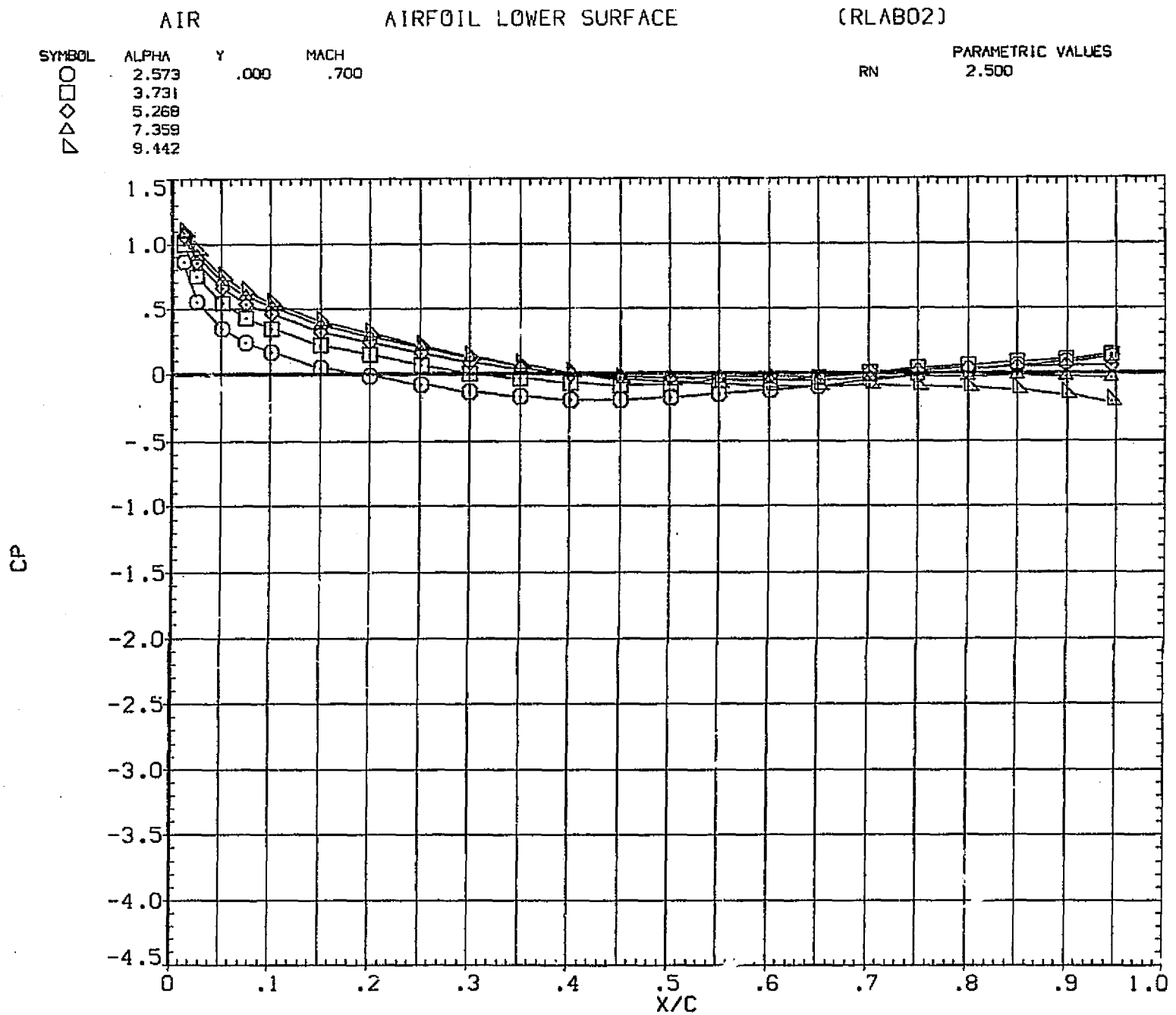


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

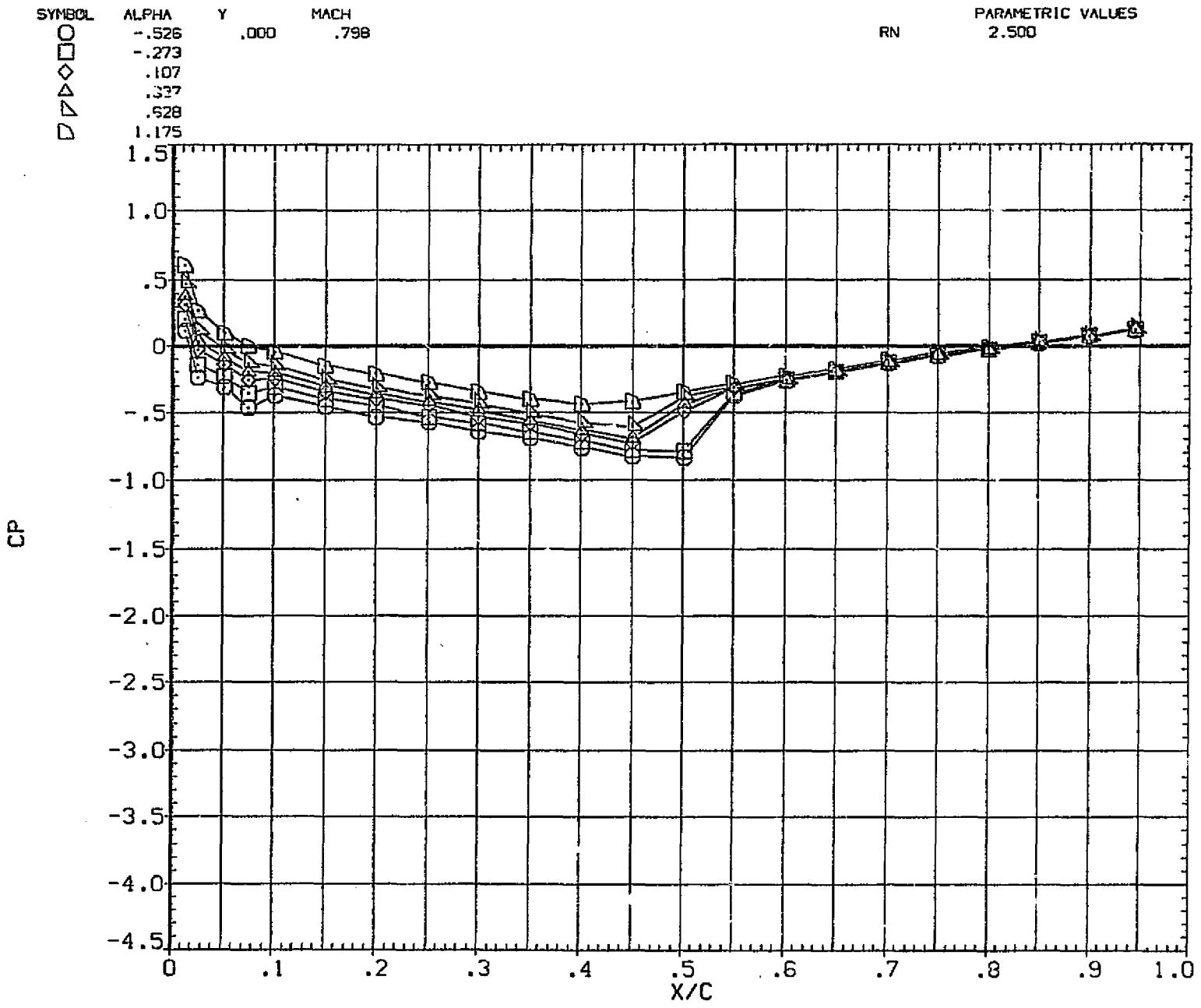


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

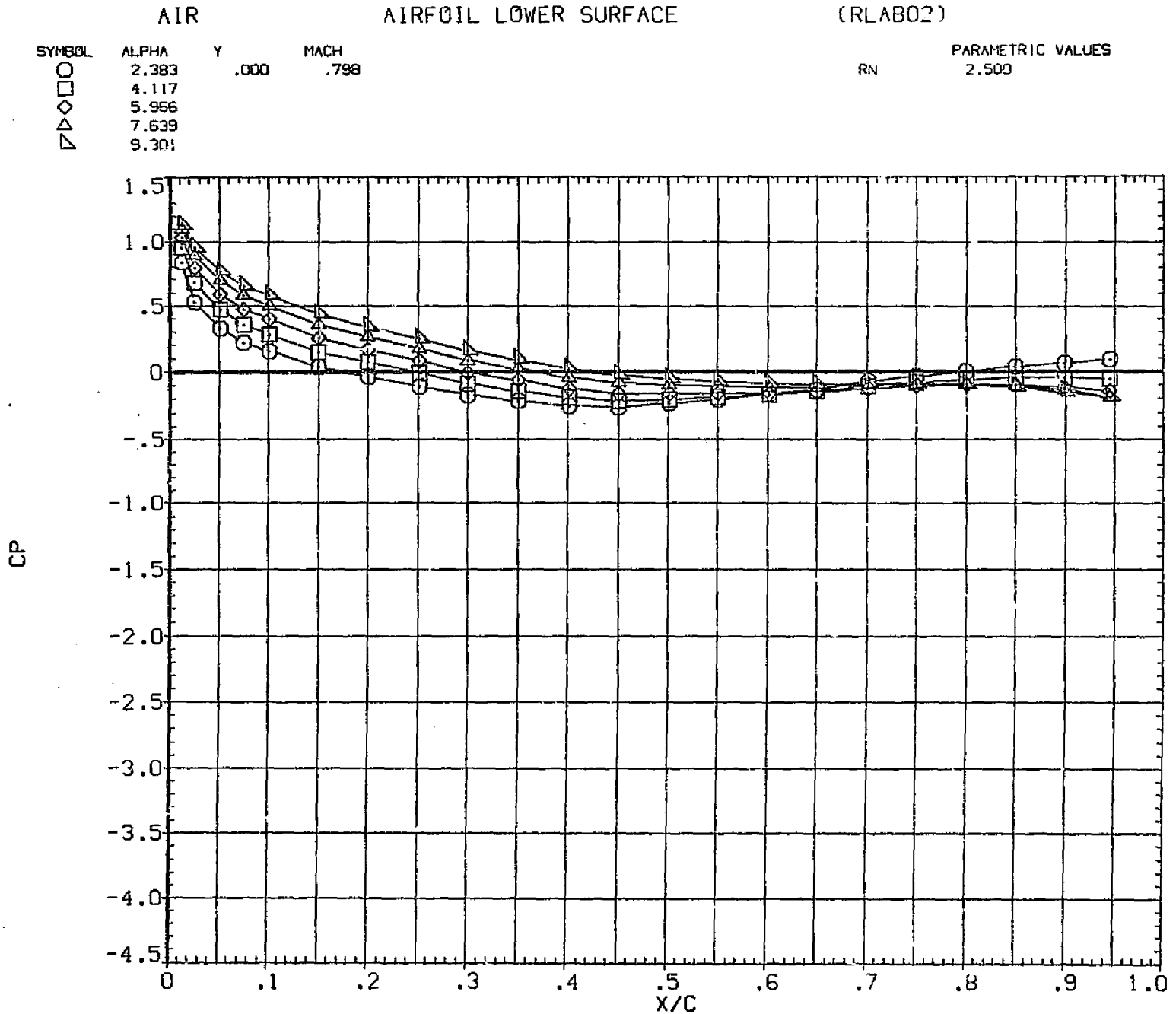


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

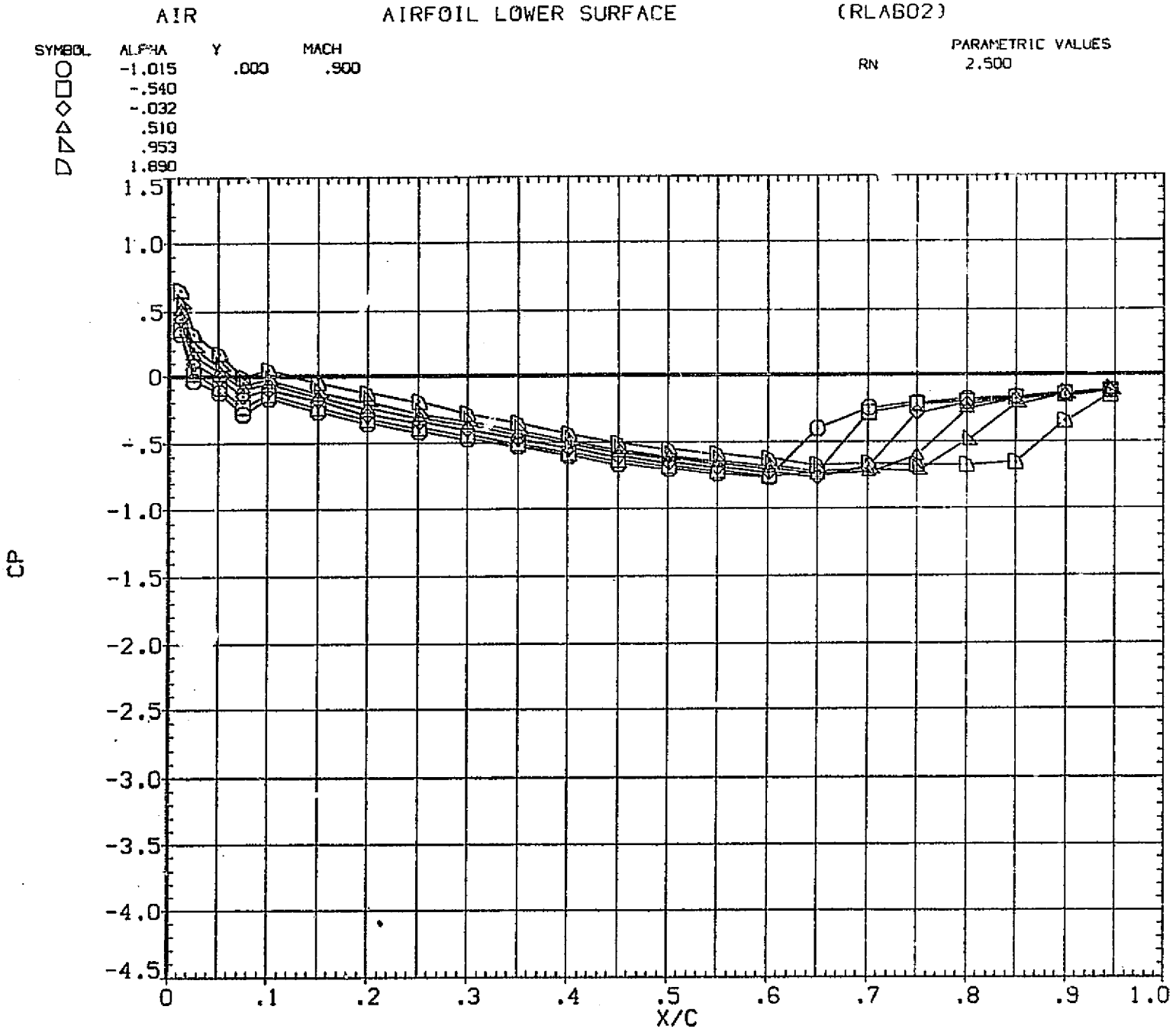


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

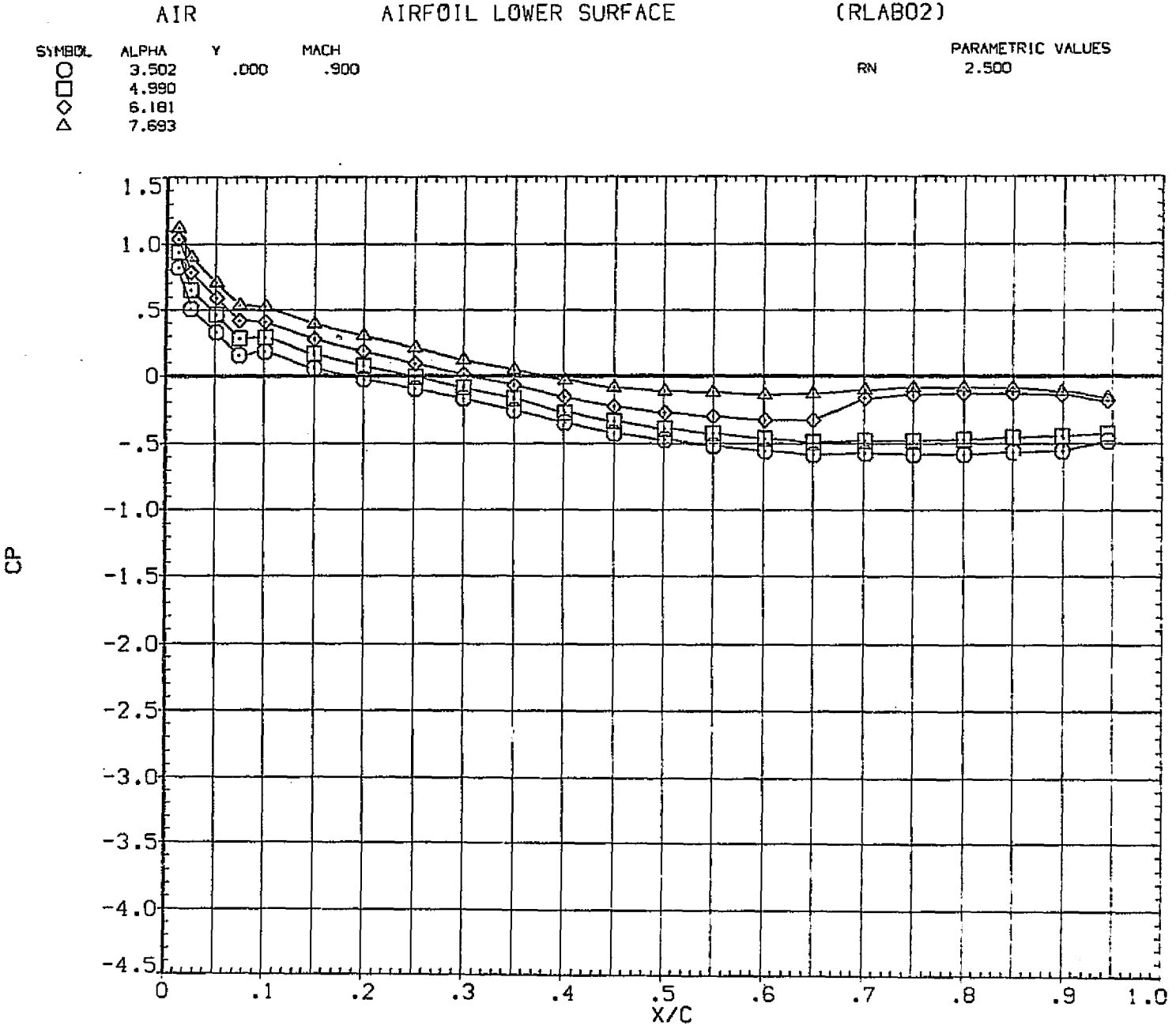


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

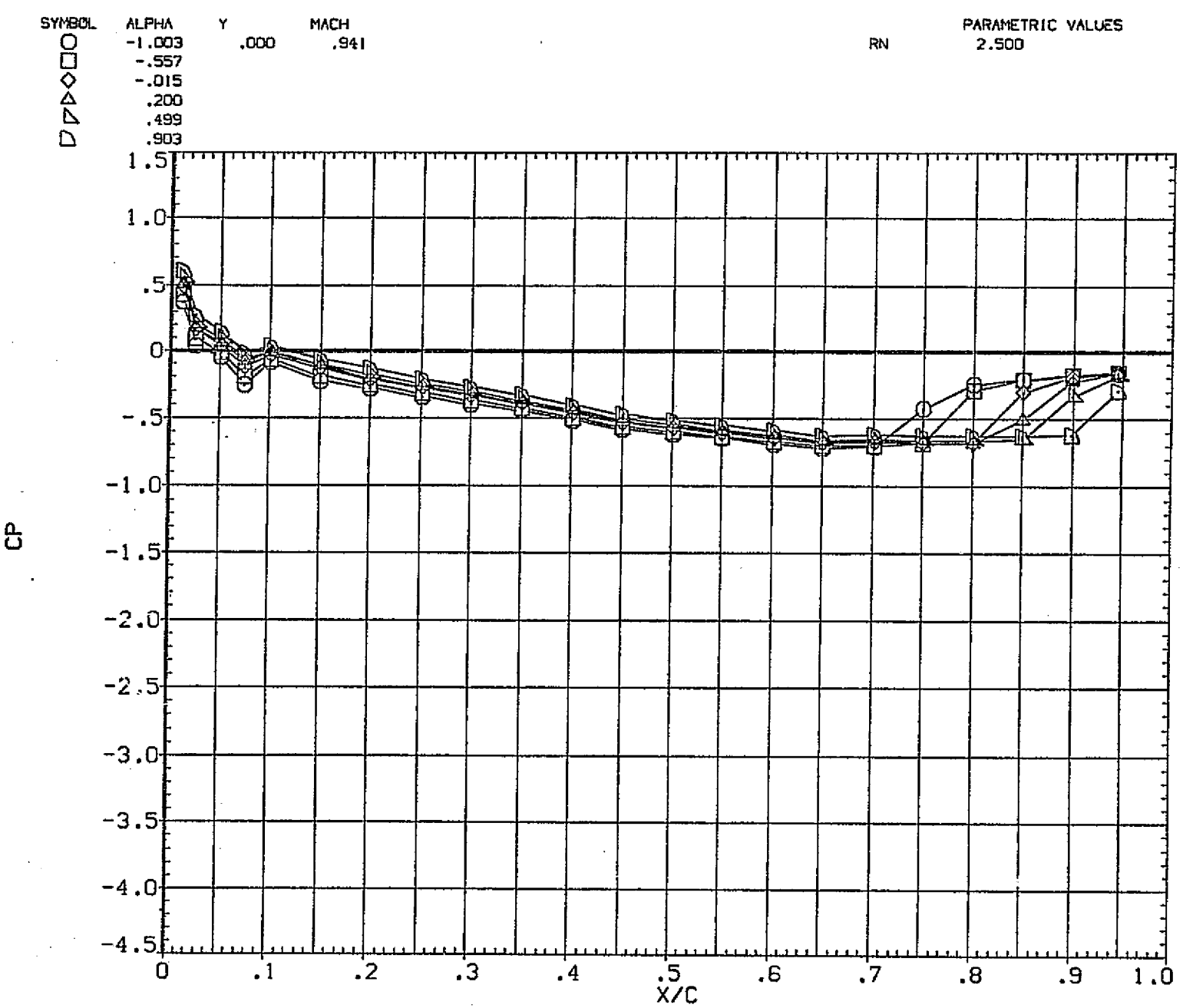


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

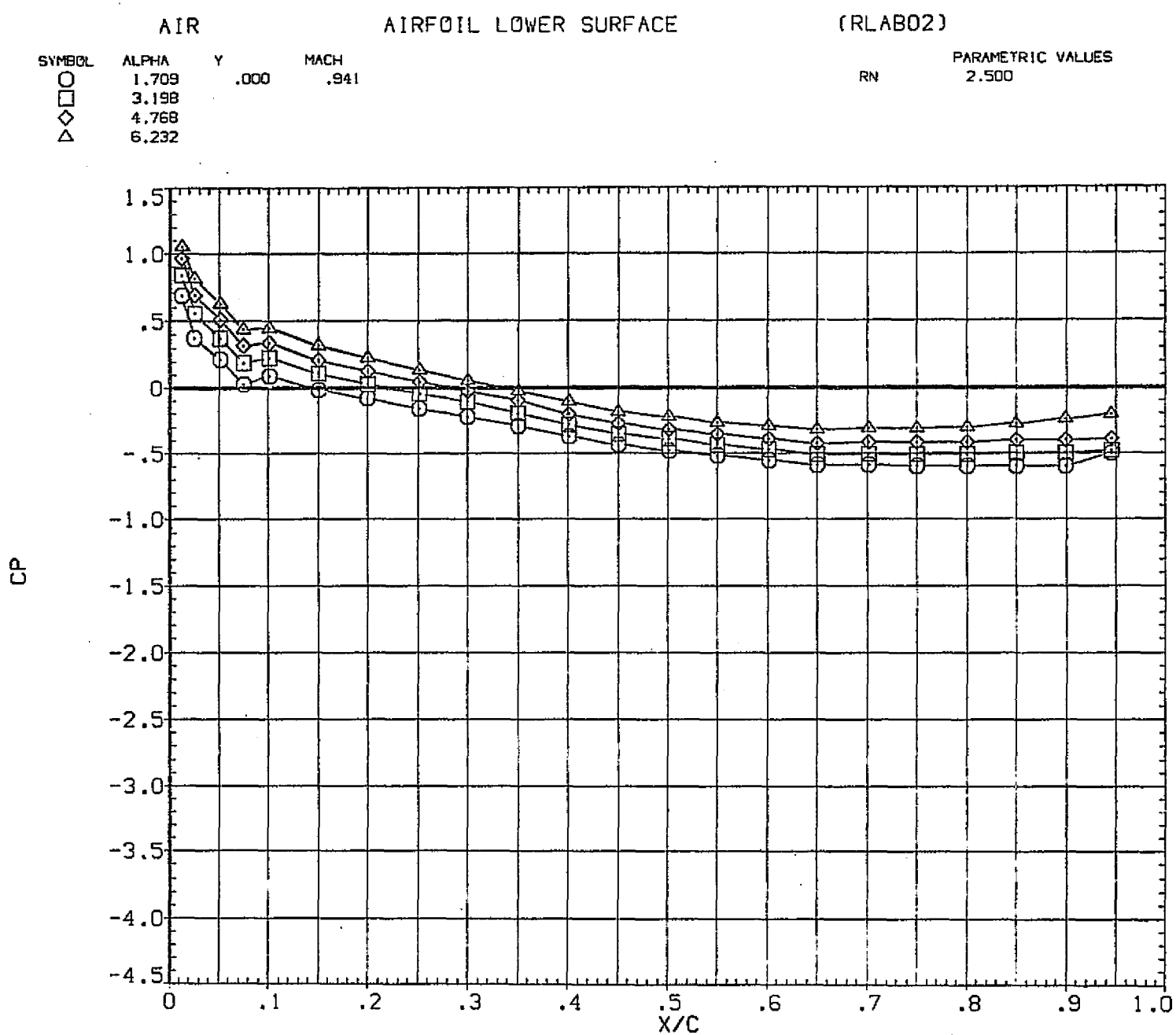


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

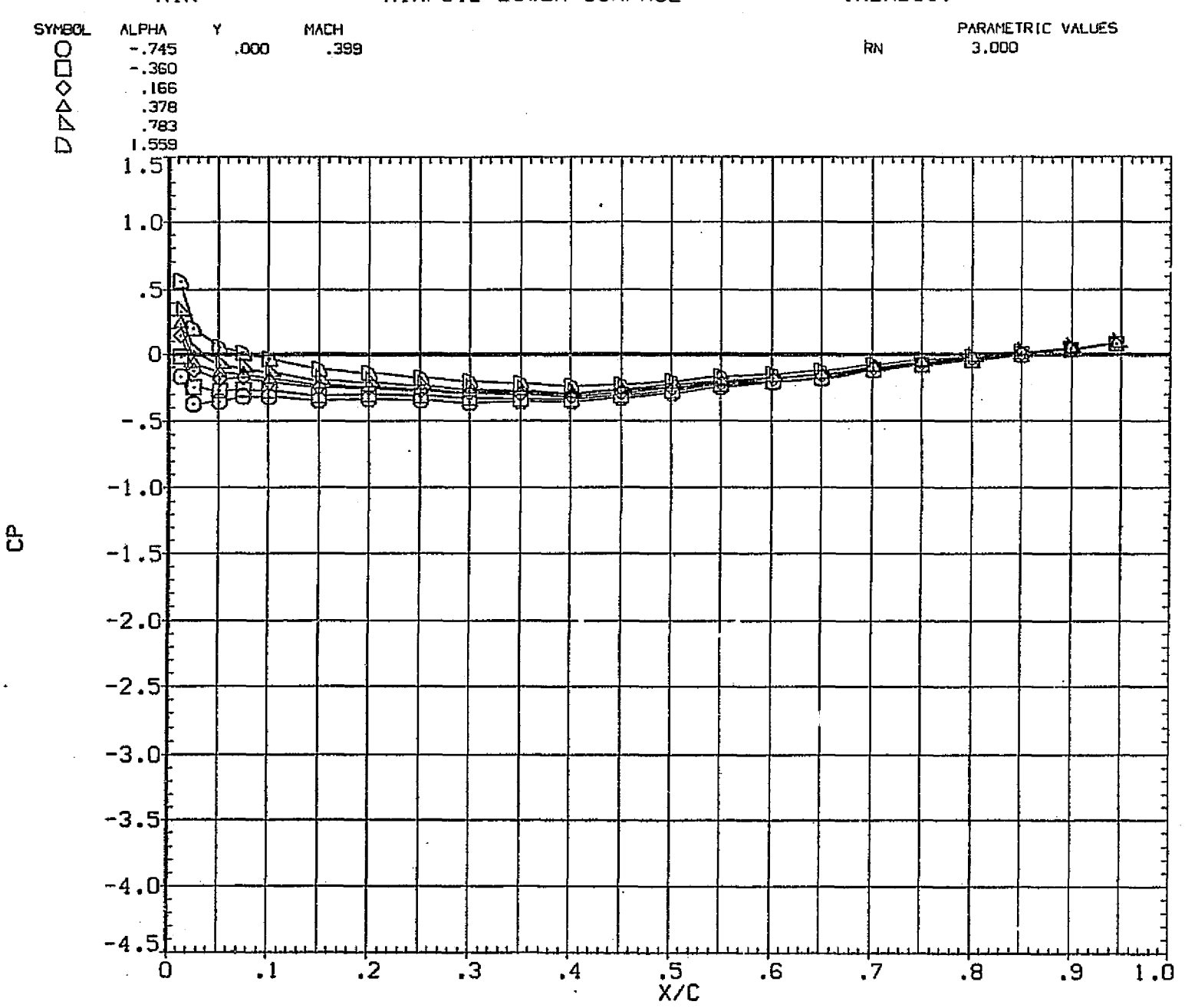


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

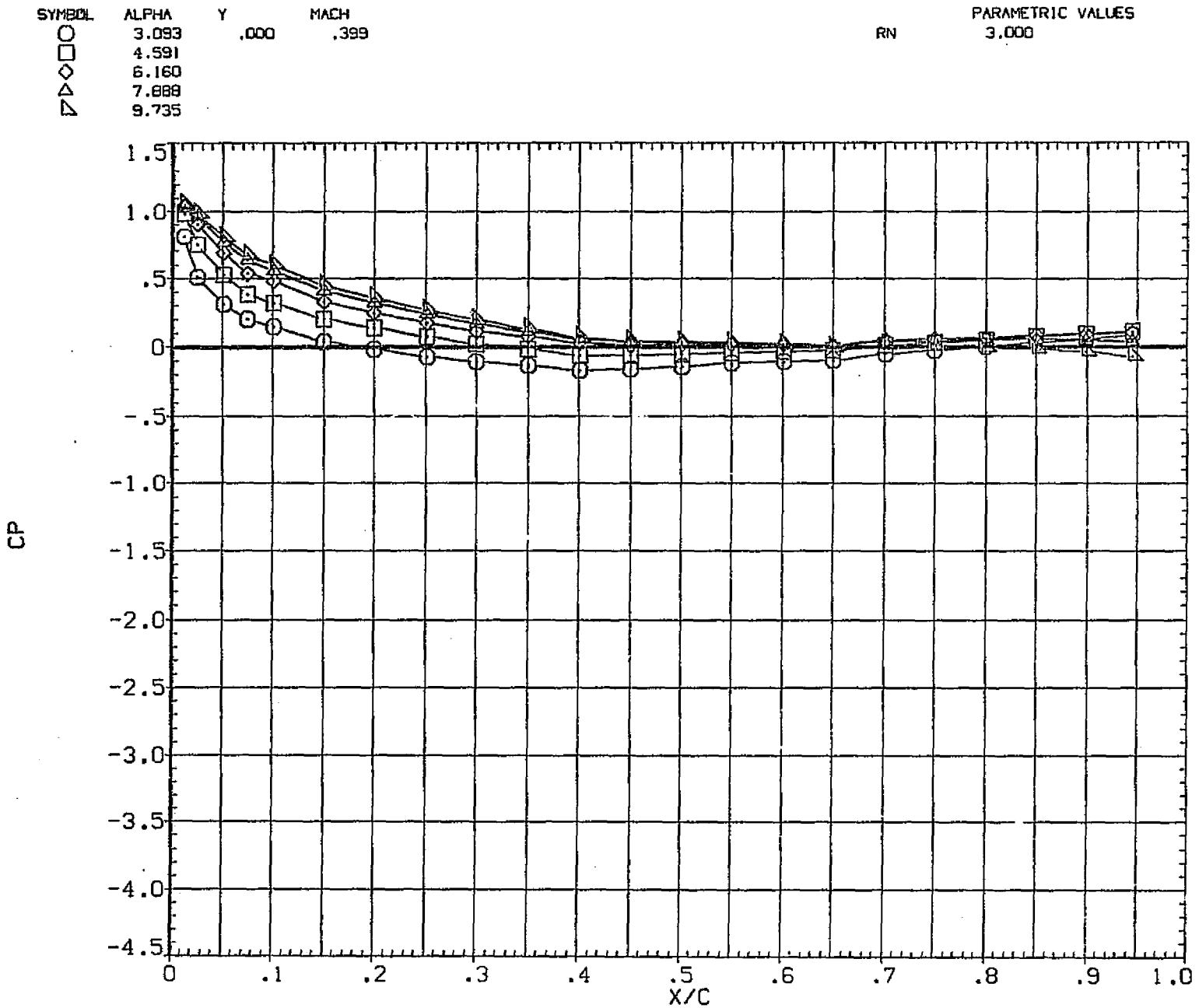


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

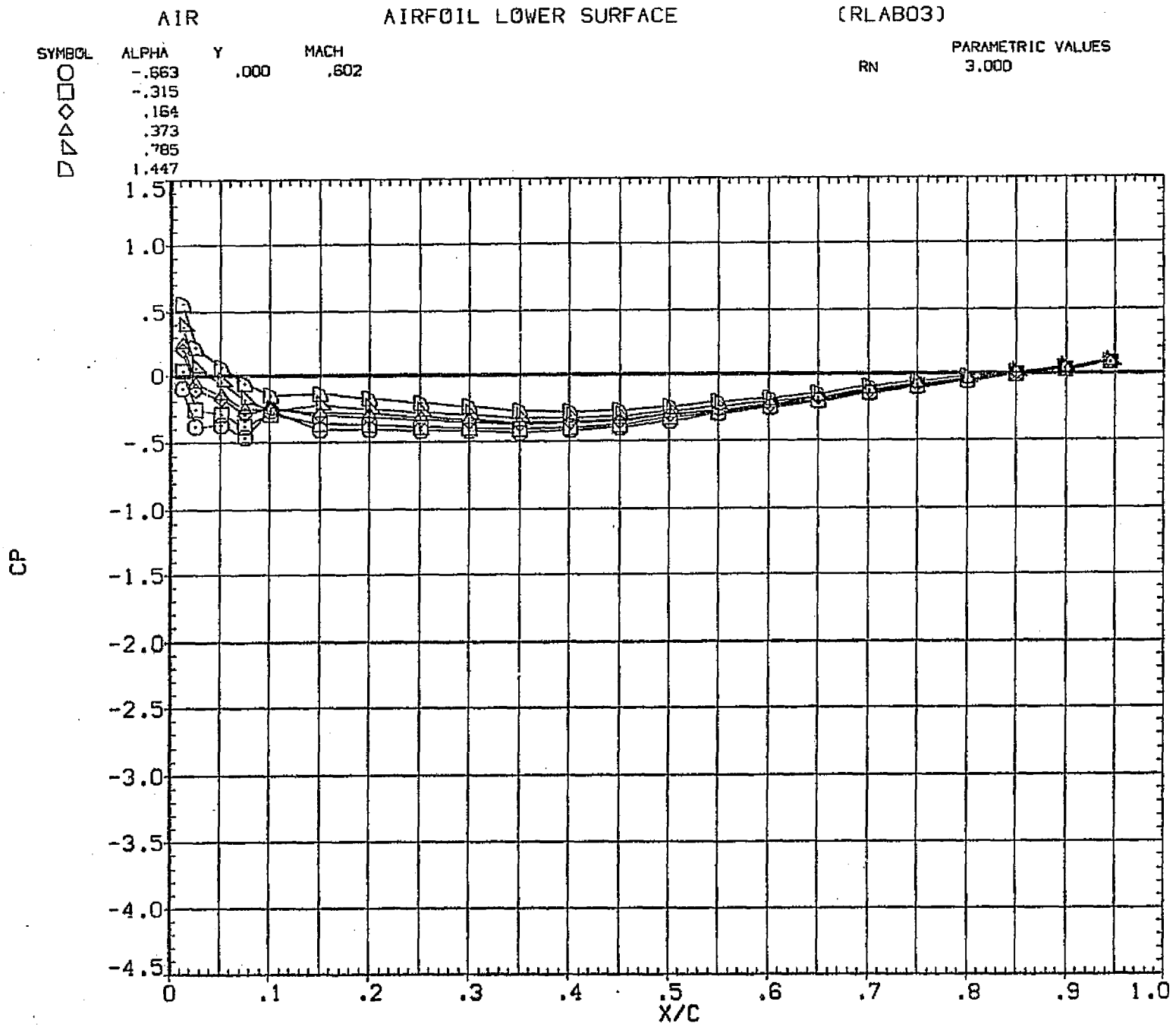


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

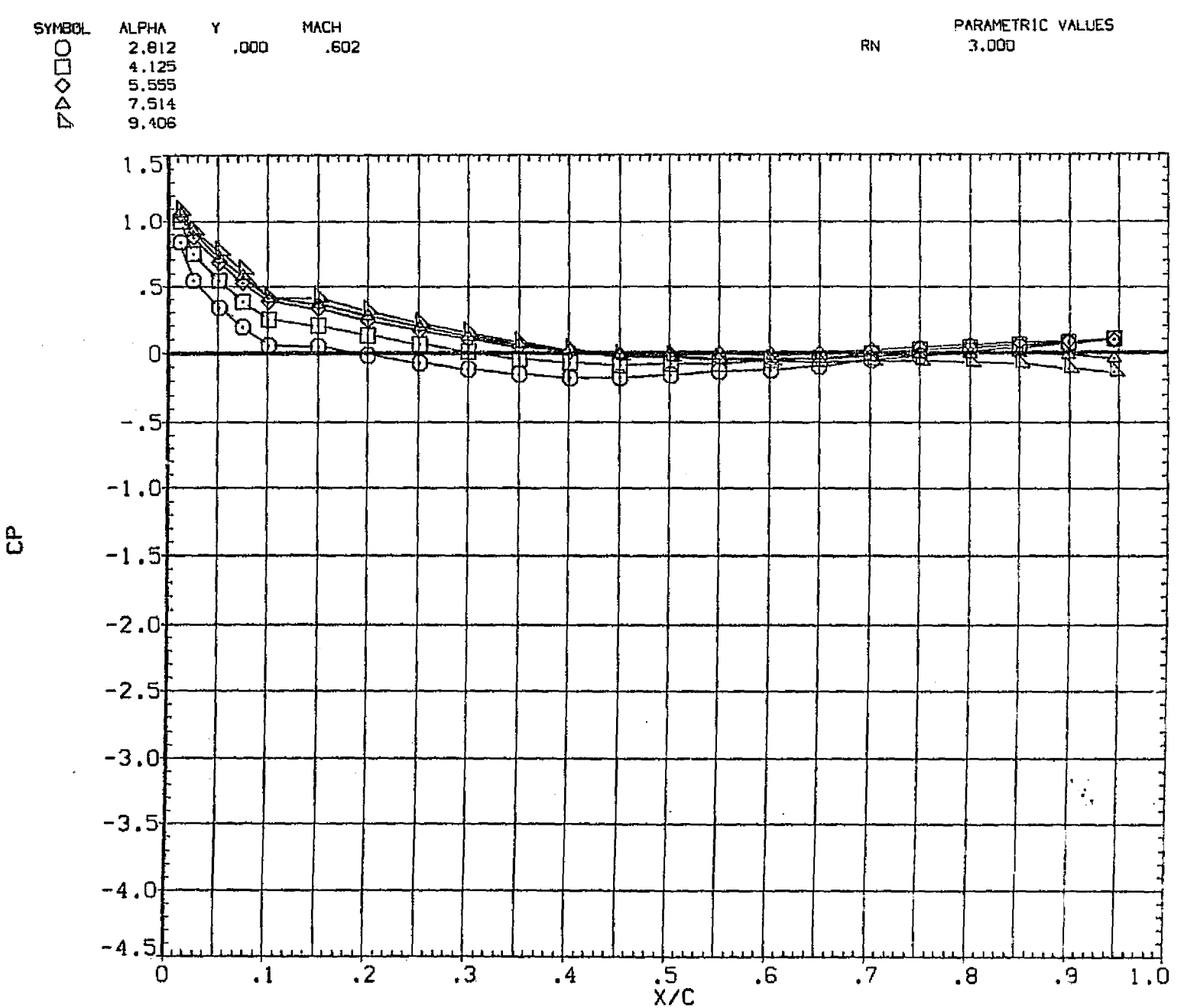
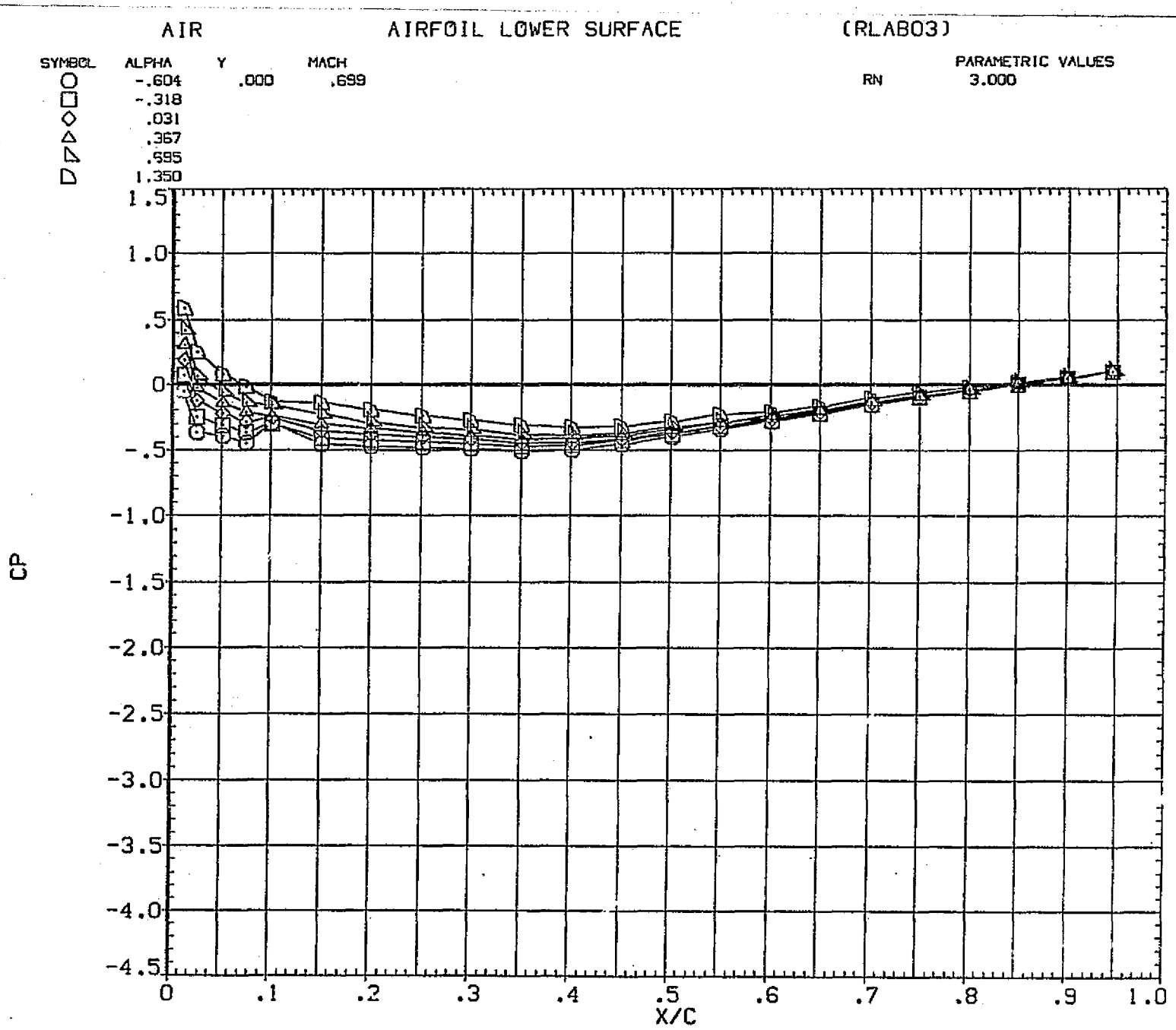


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR



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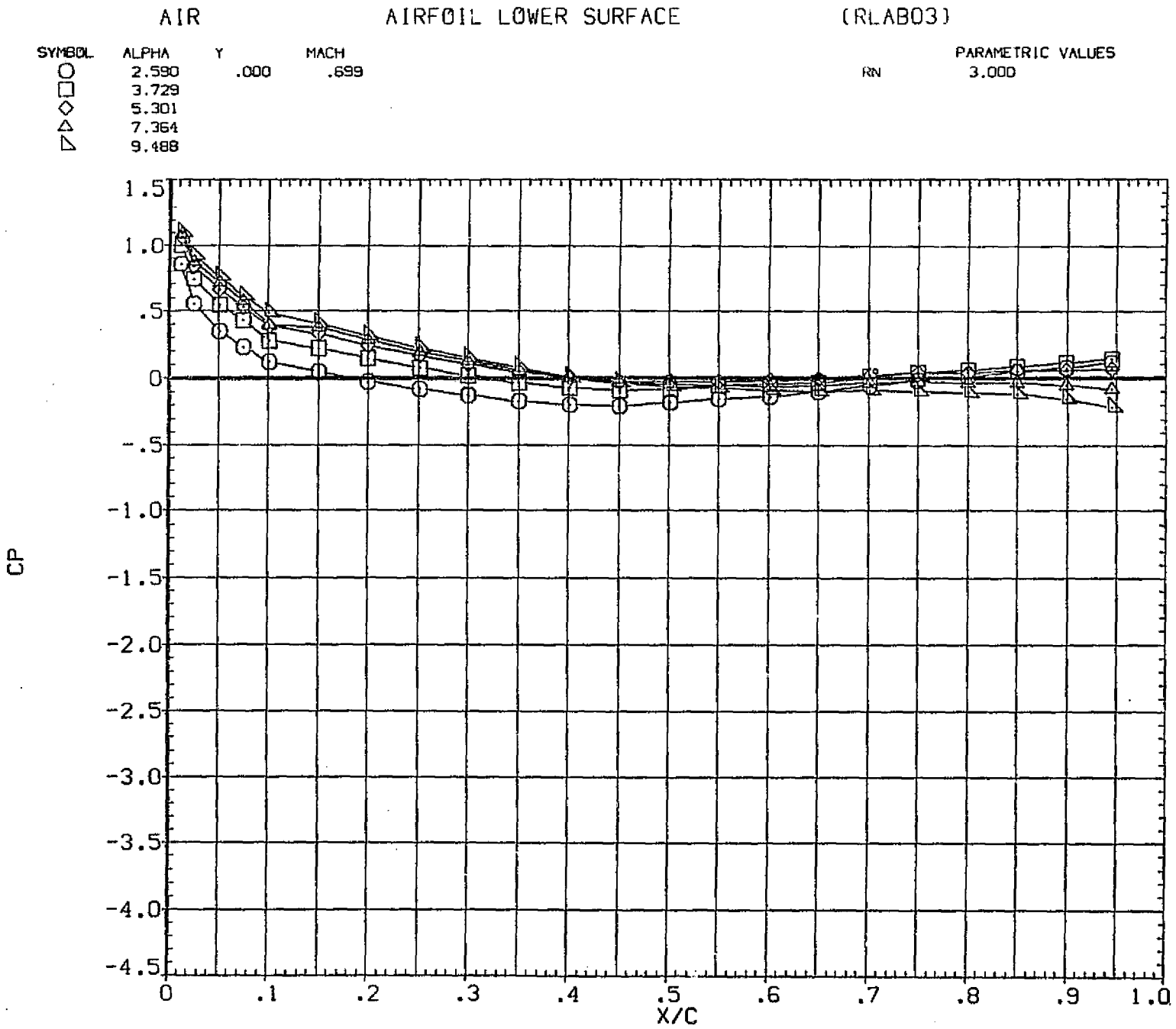

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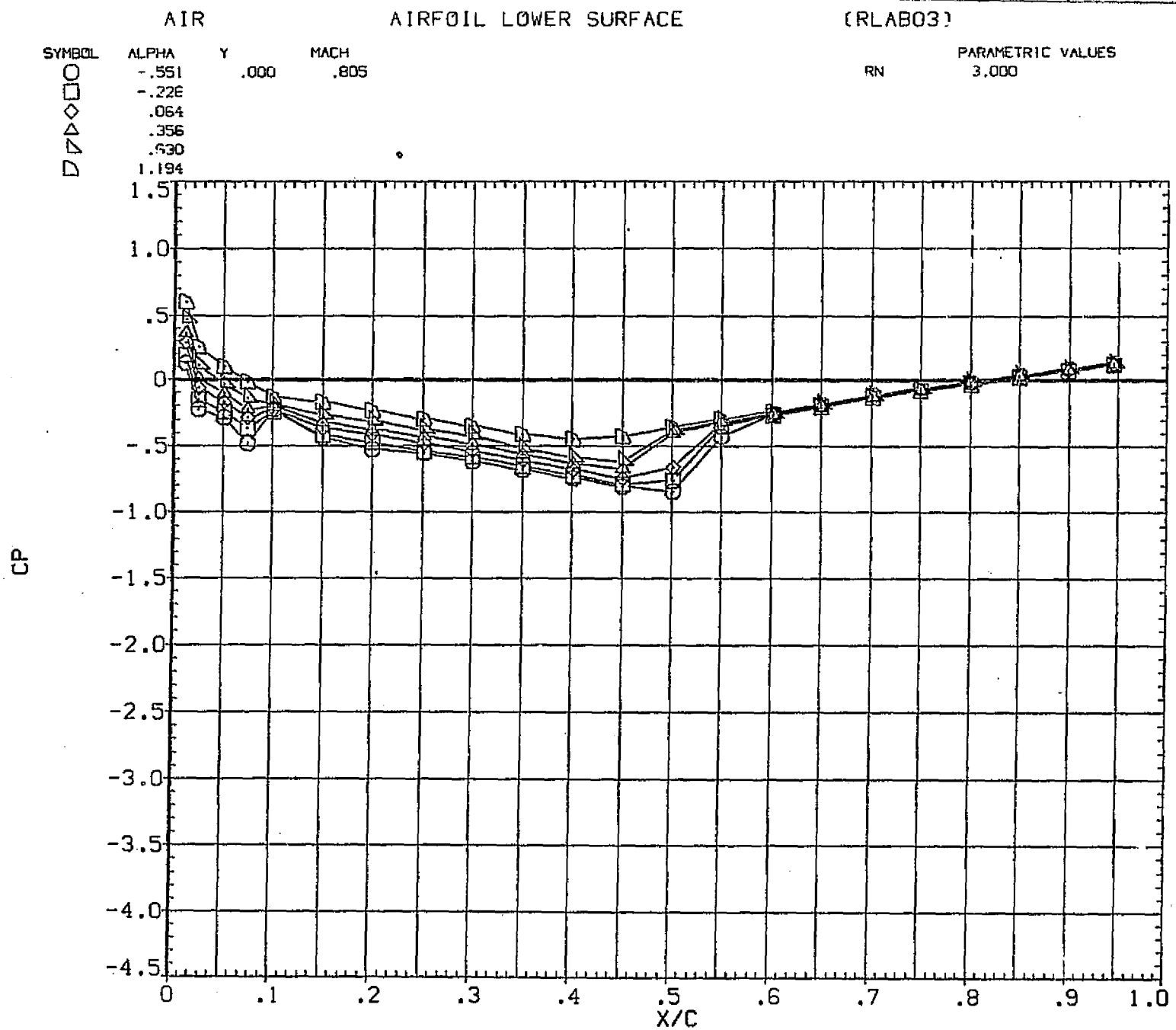
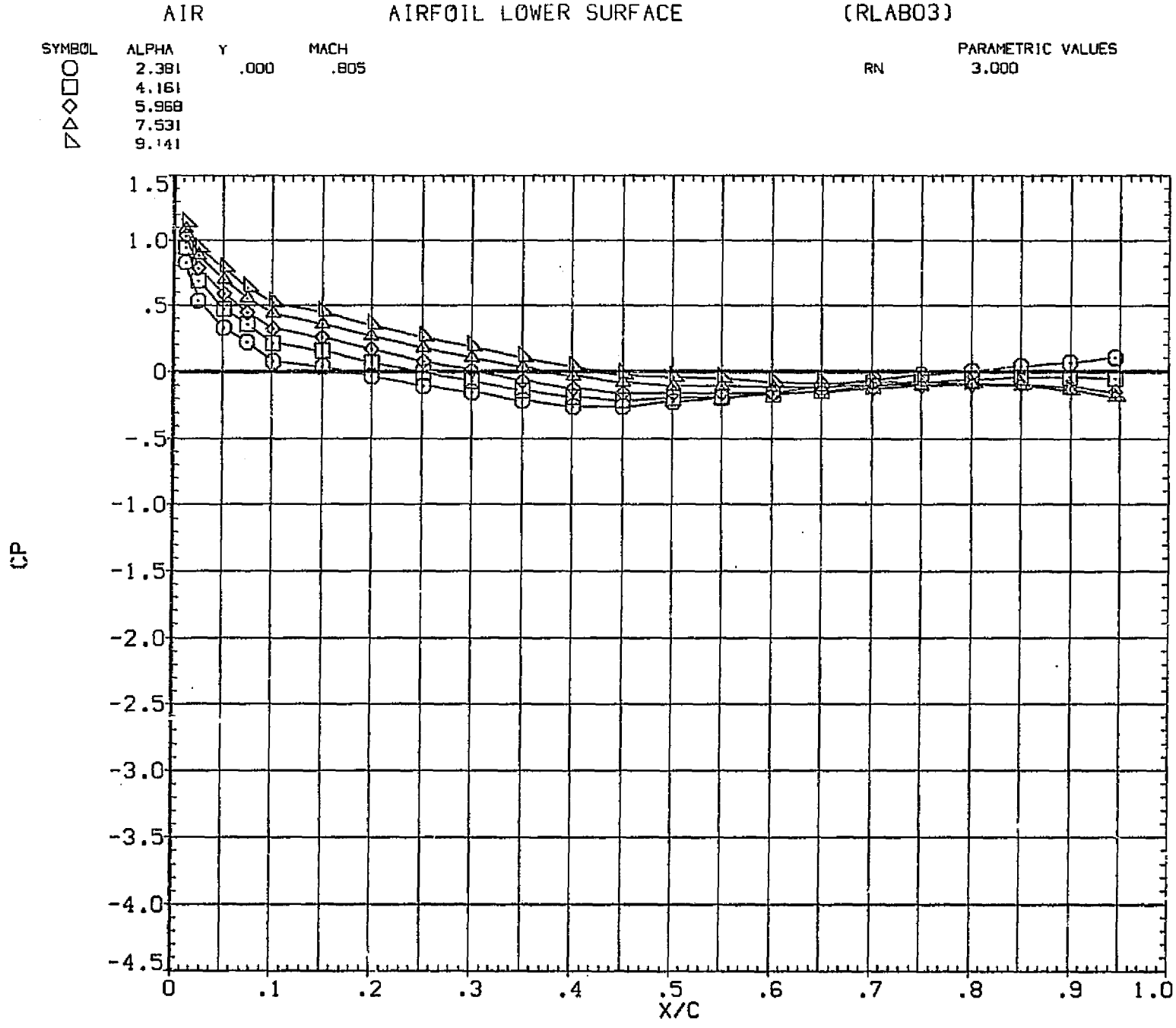


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR



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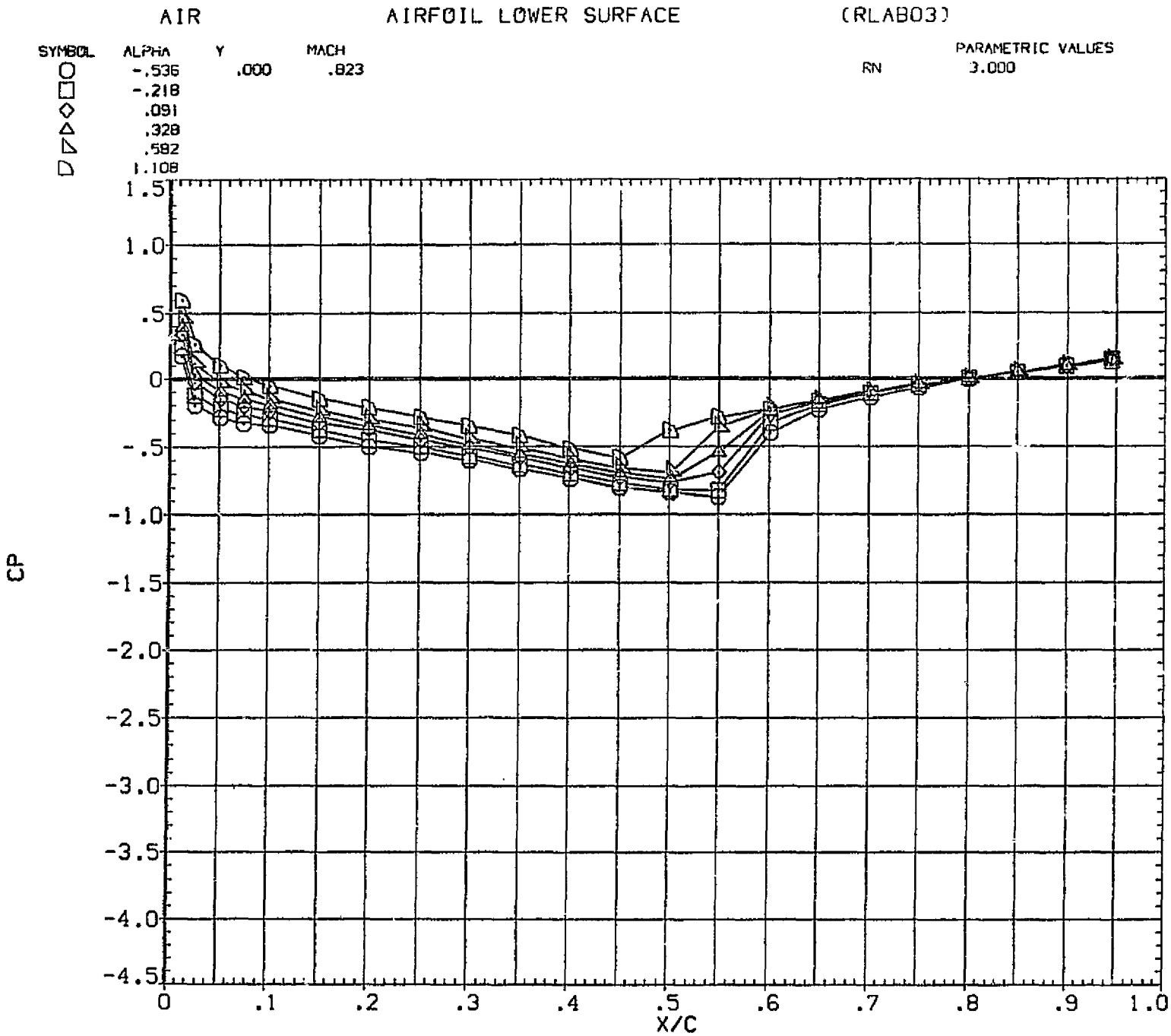

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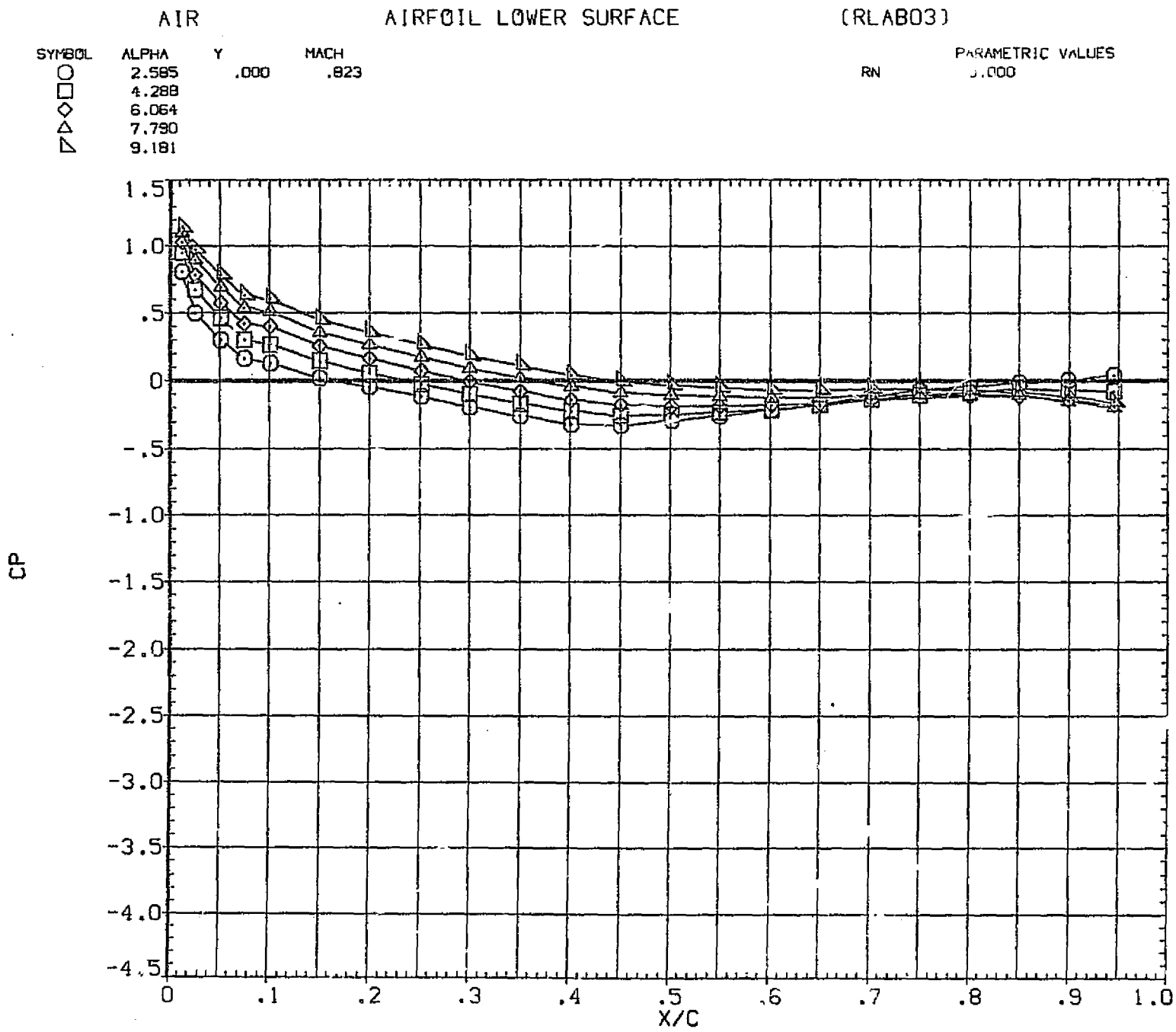
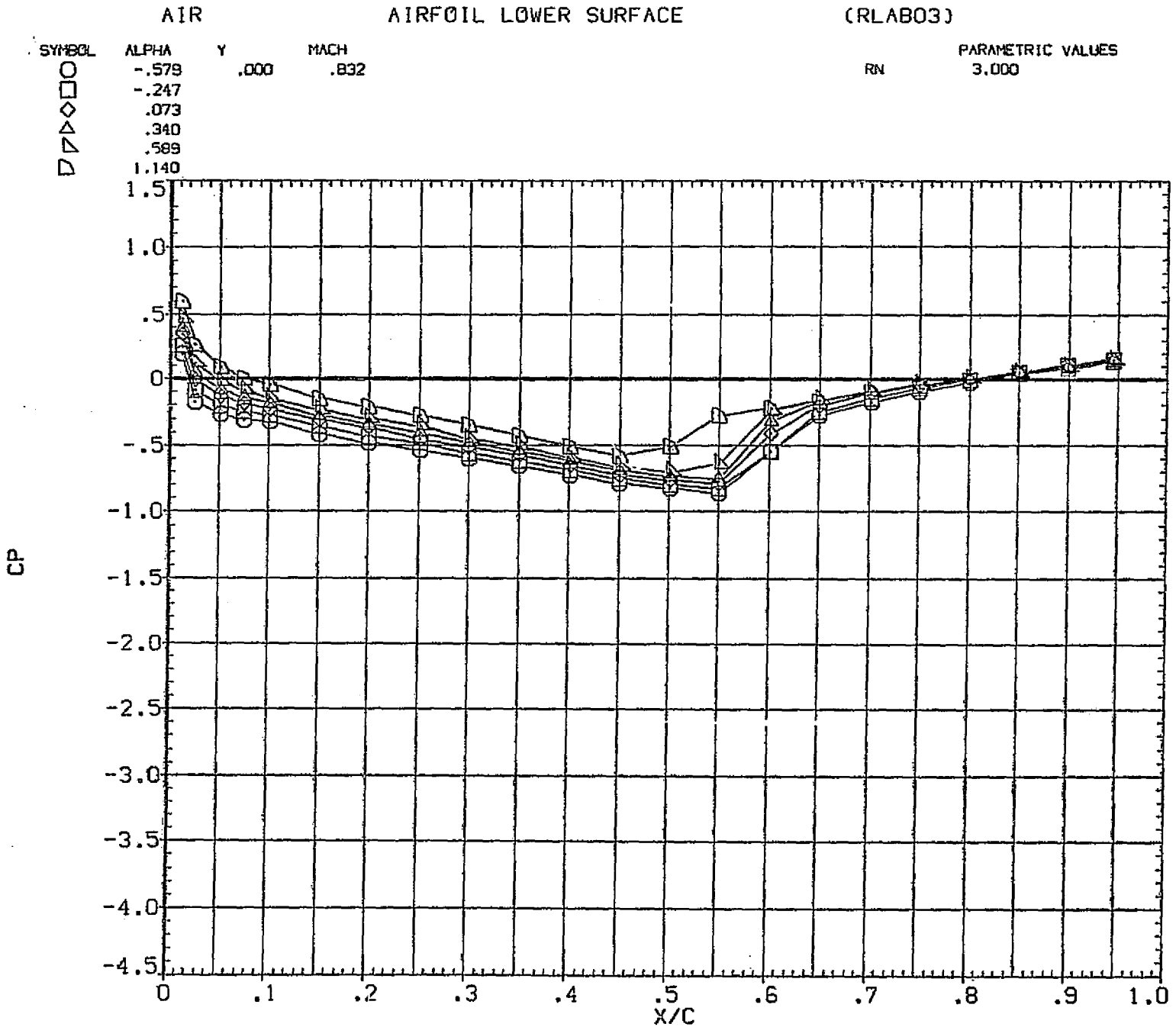


FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR



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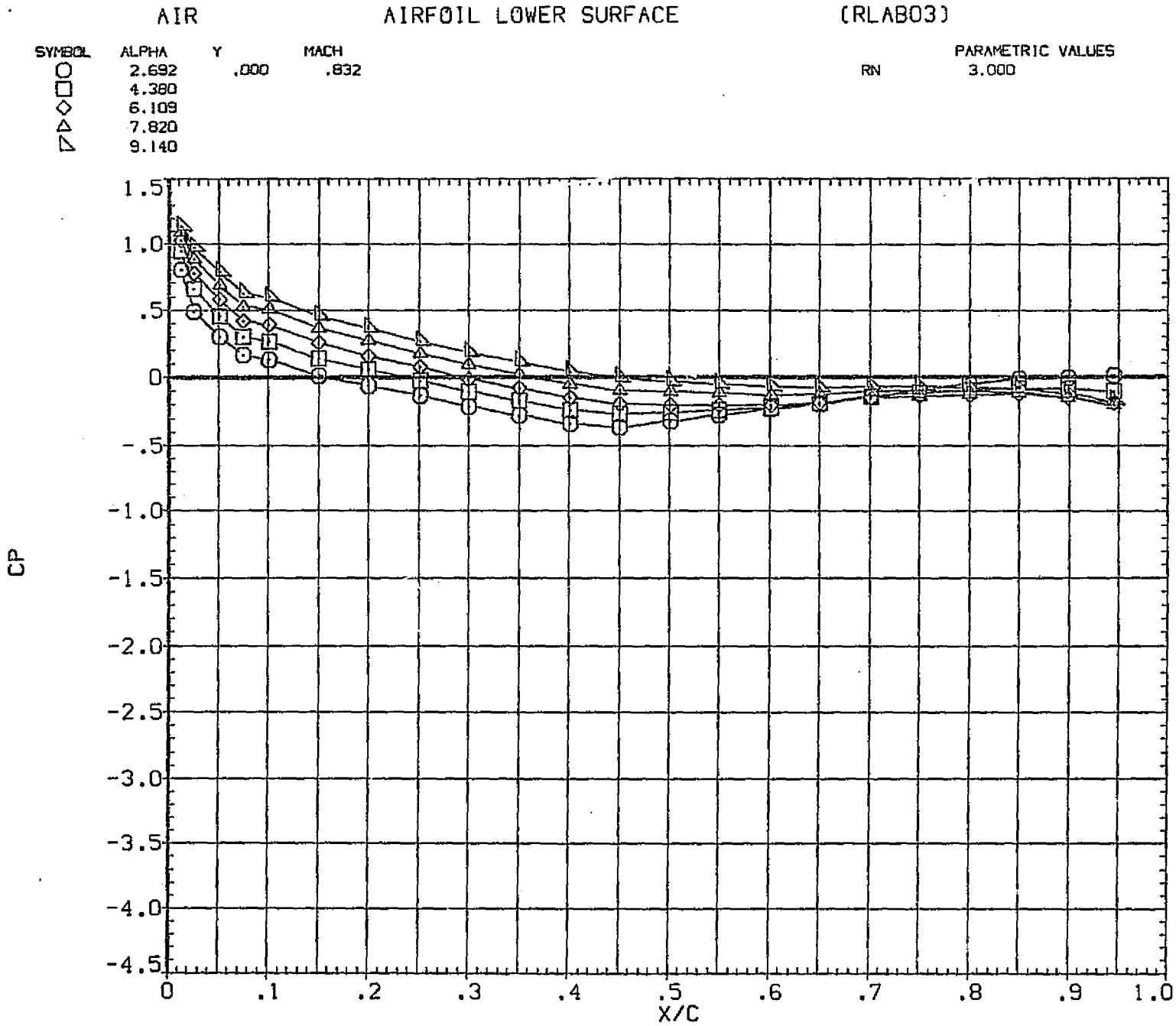

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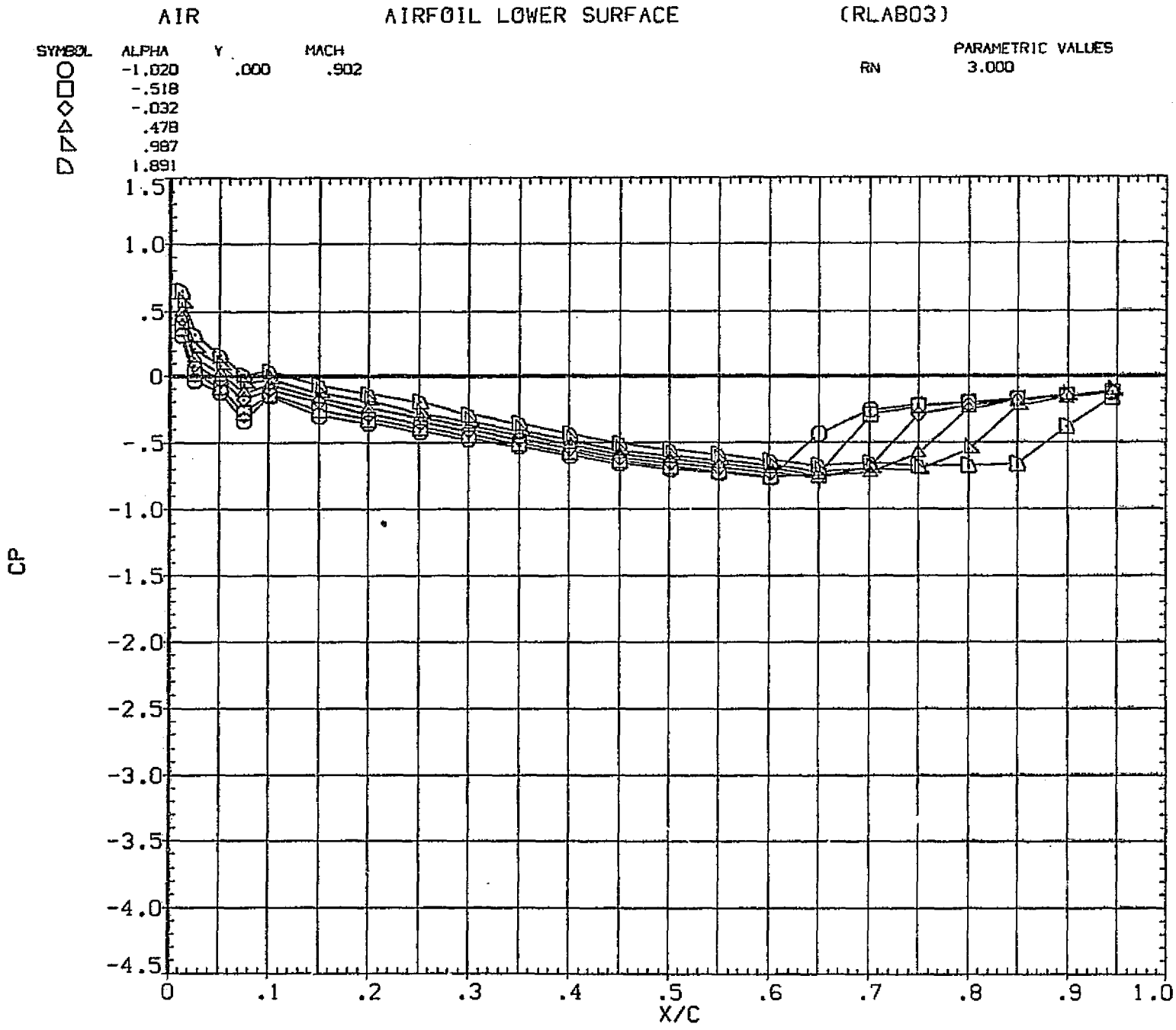

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

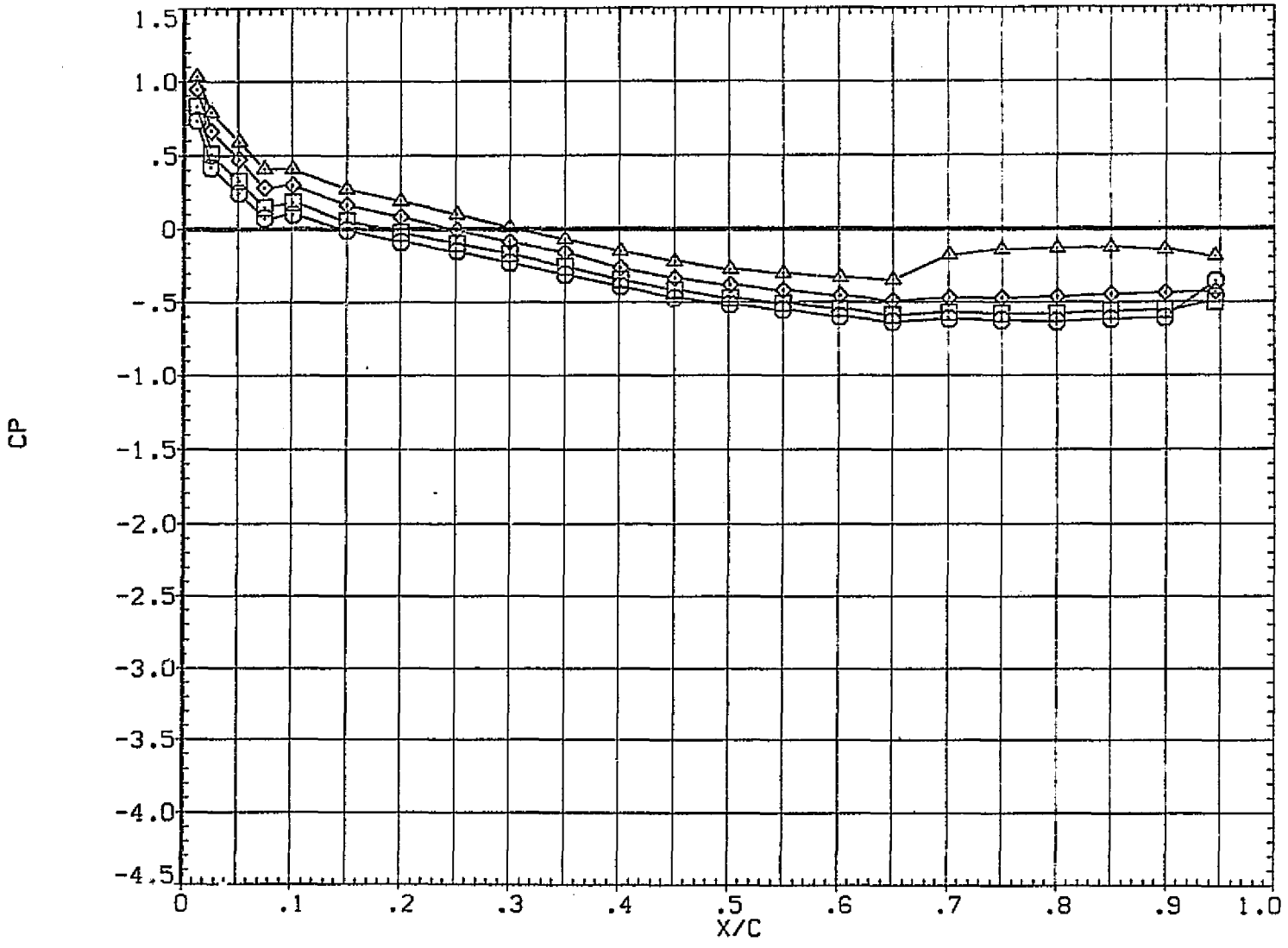

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

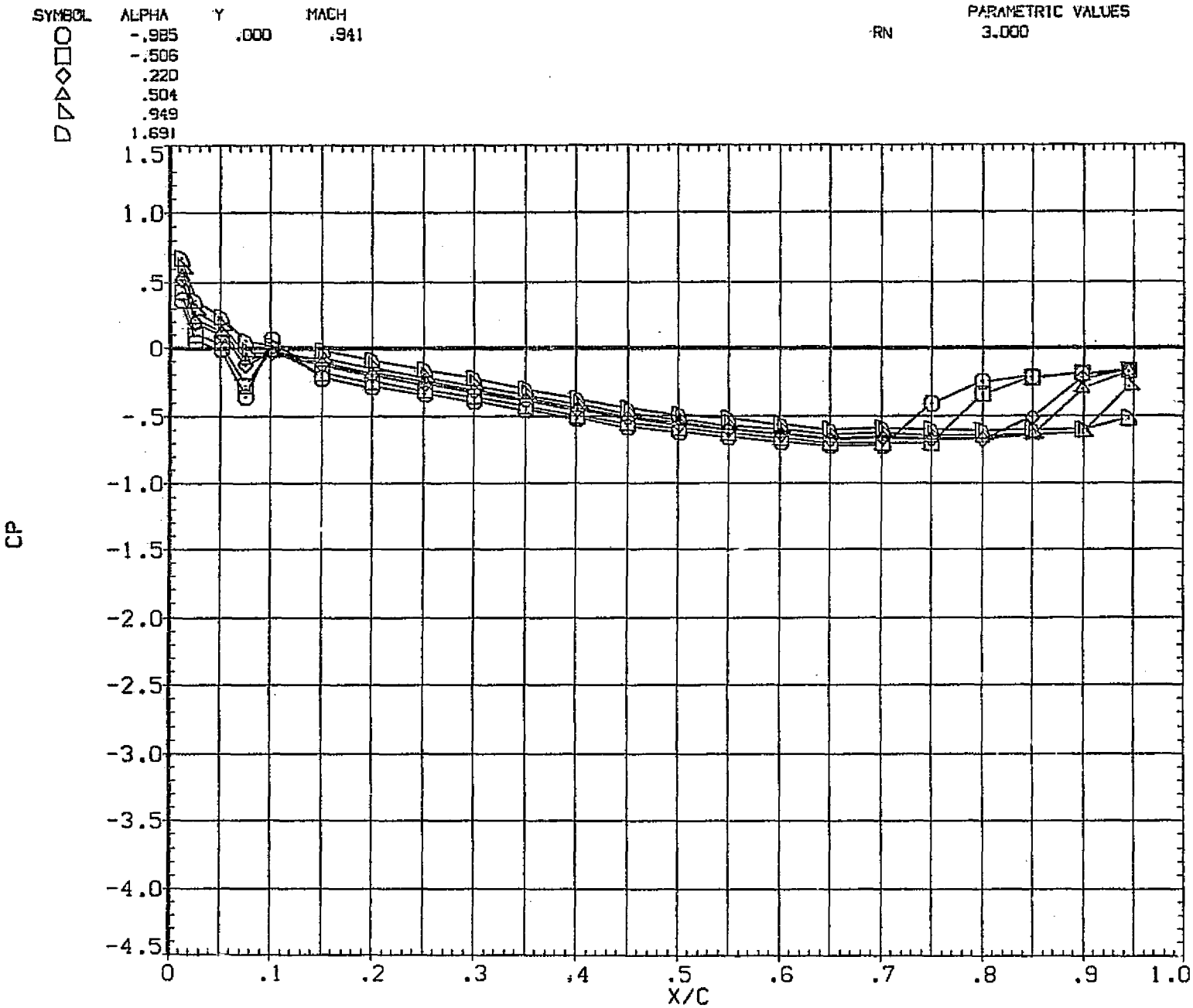

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL LOWER SURFACE (RLAB03)

SYMBOL	ALPHA	Y	MACH
○	3.185	.000	.941
□	4.792		

PARAMETRIC VALUES

RN 3.000

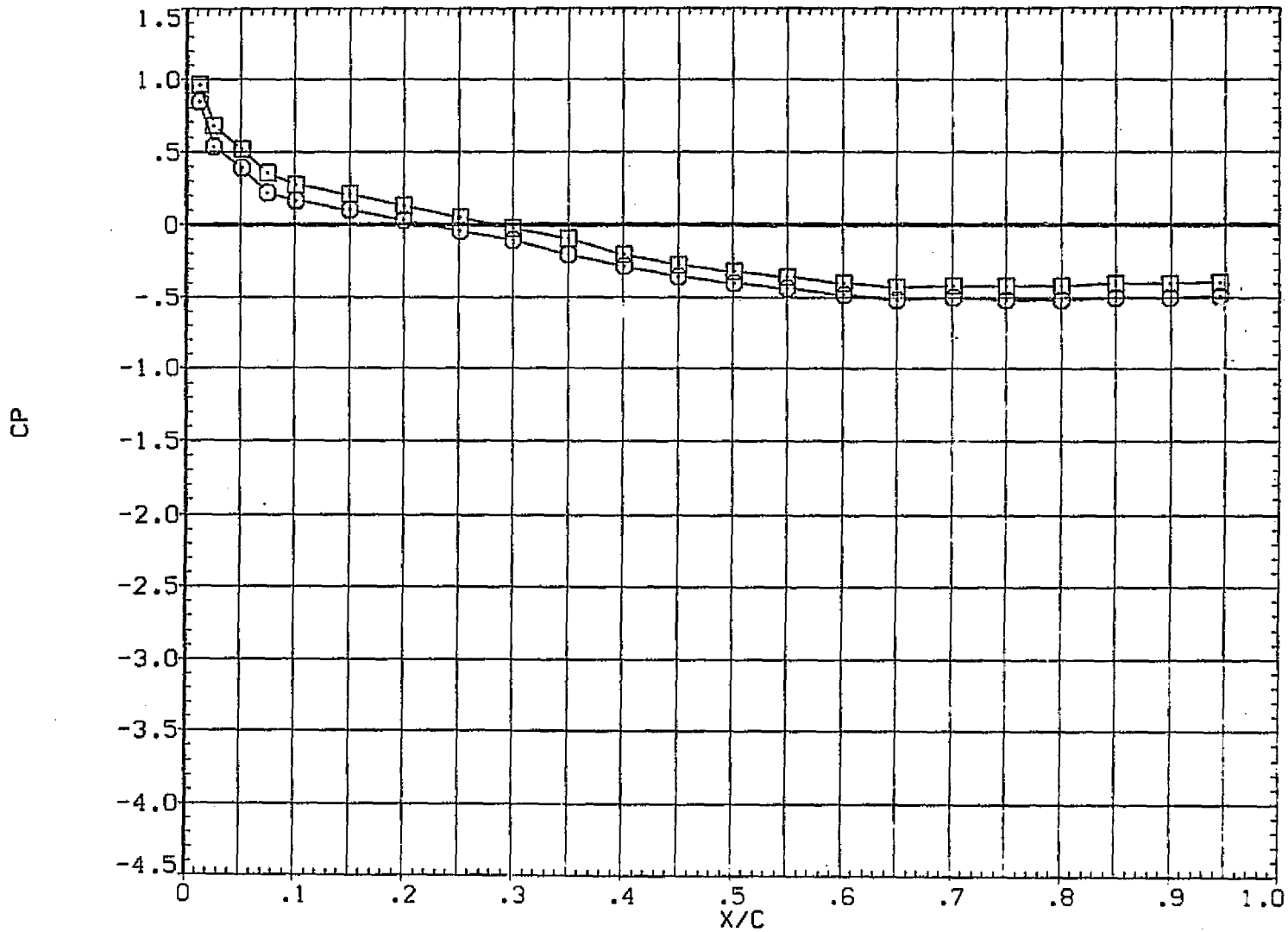

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

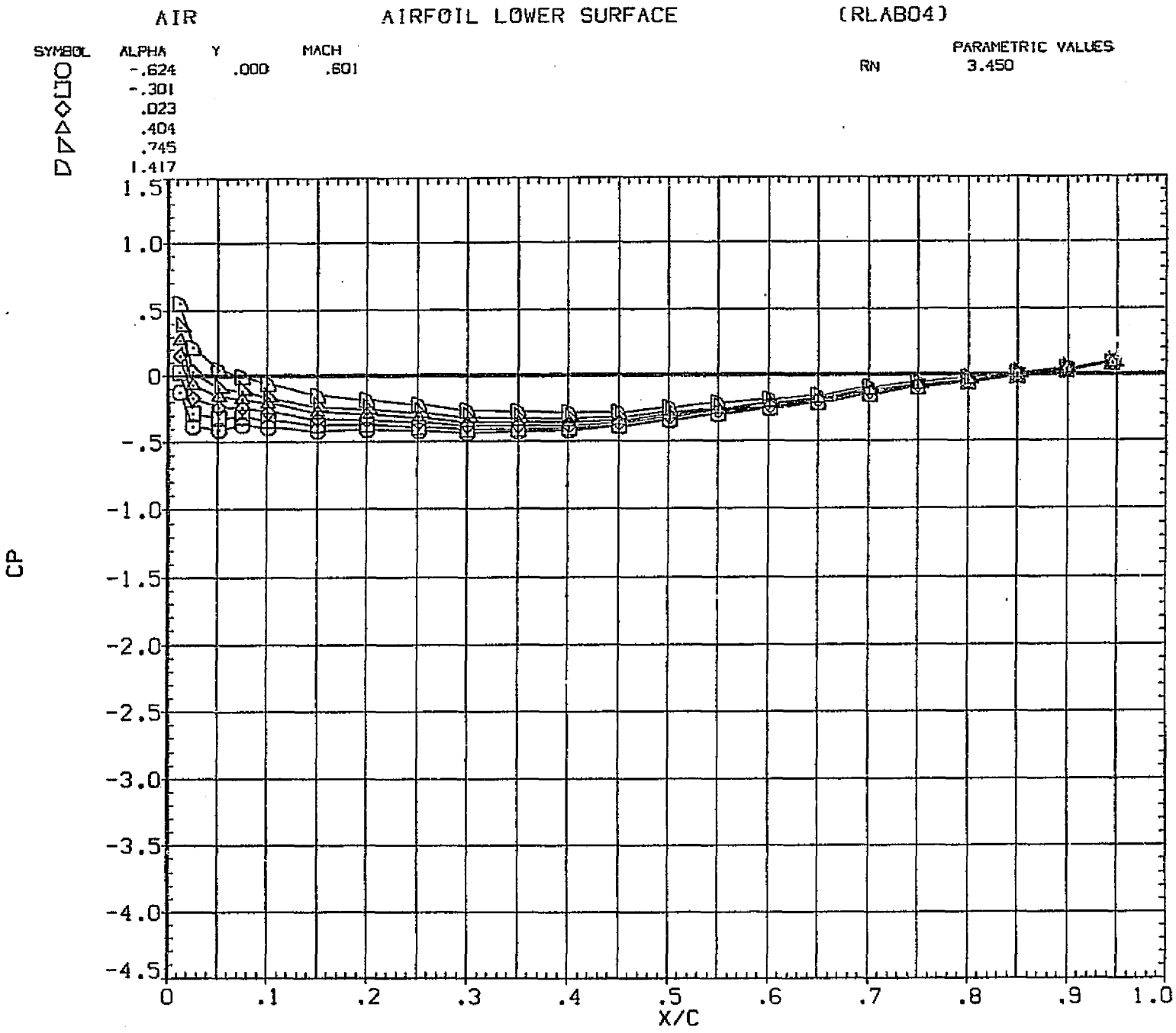

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

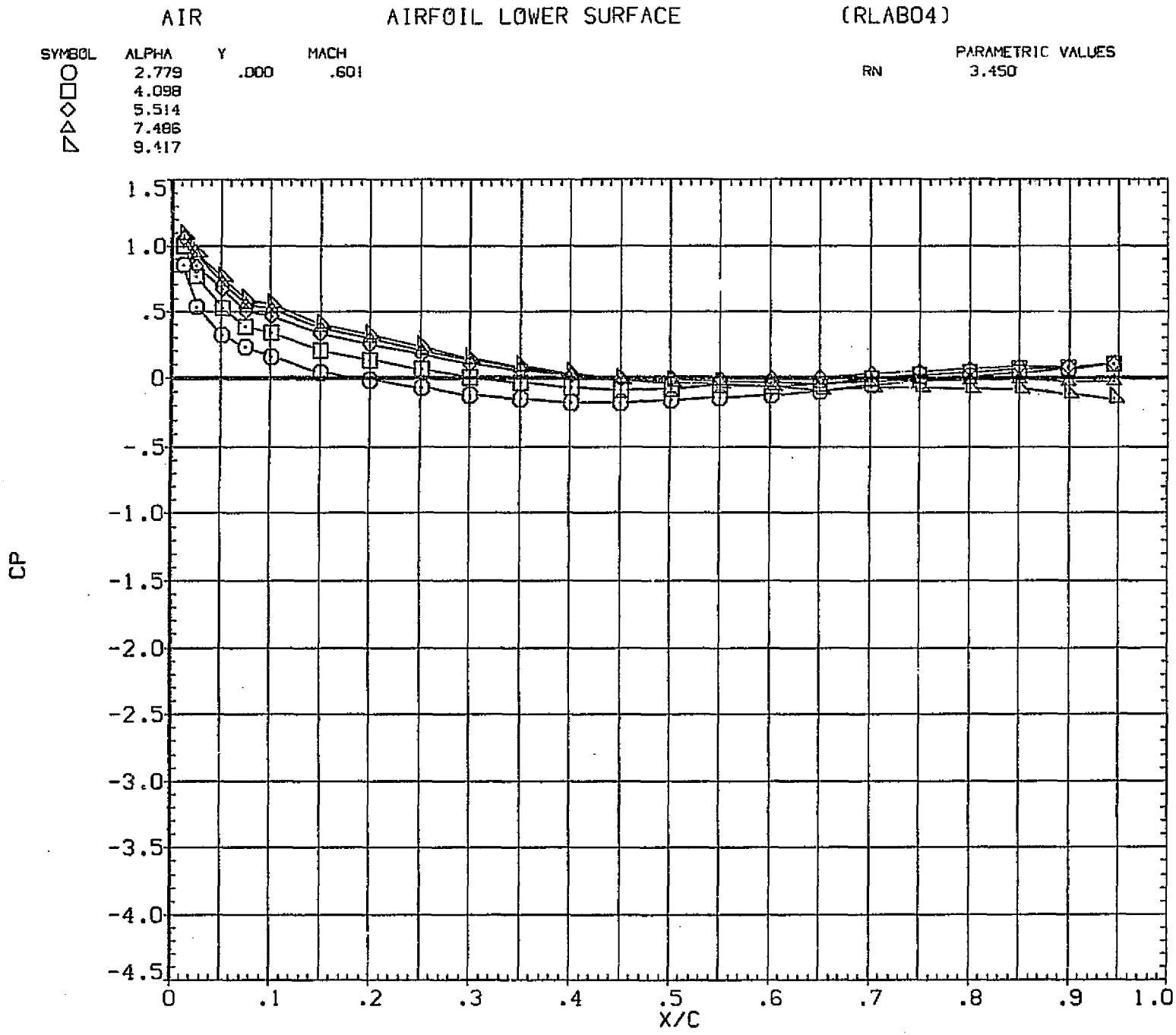

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

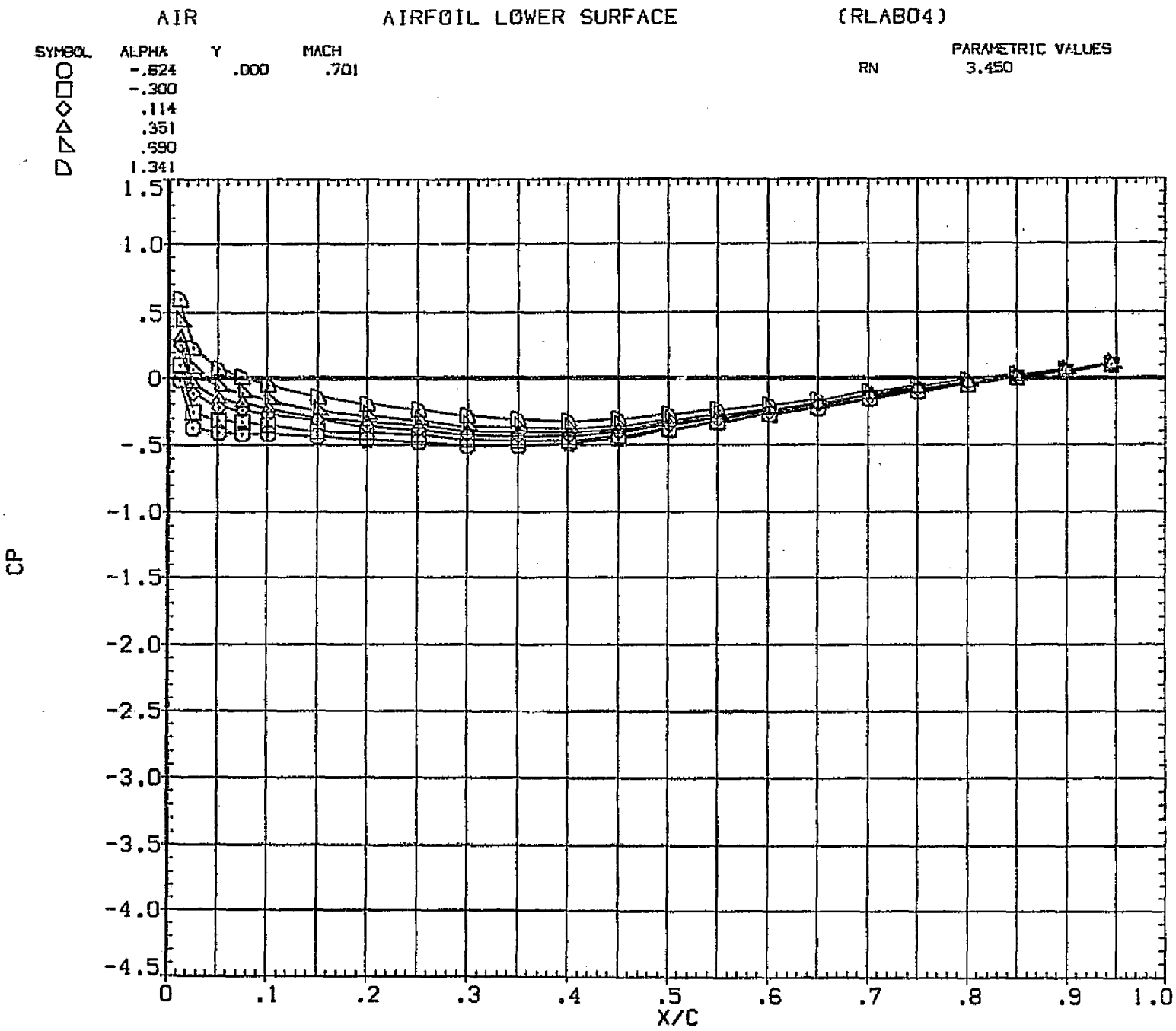

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

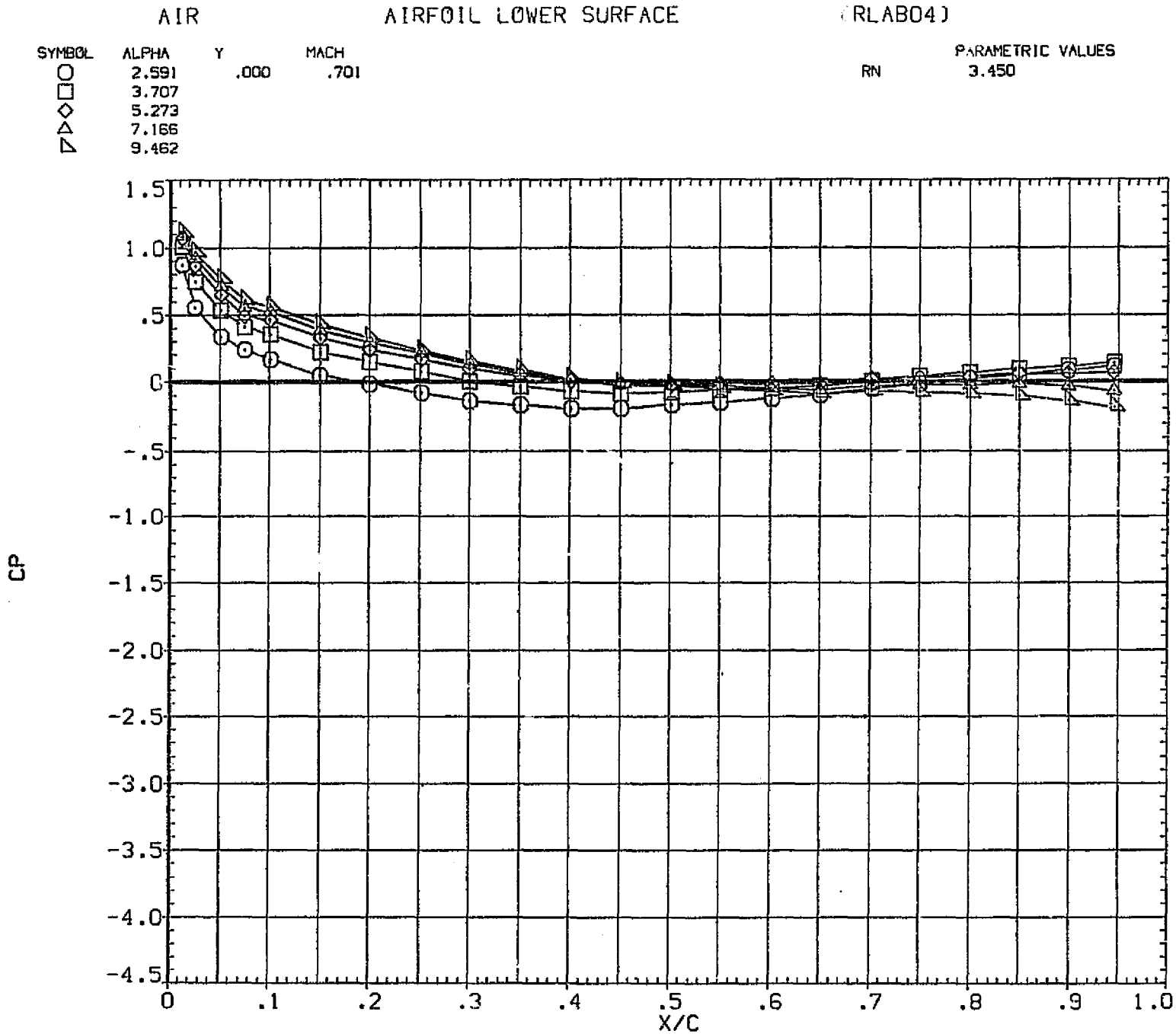

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

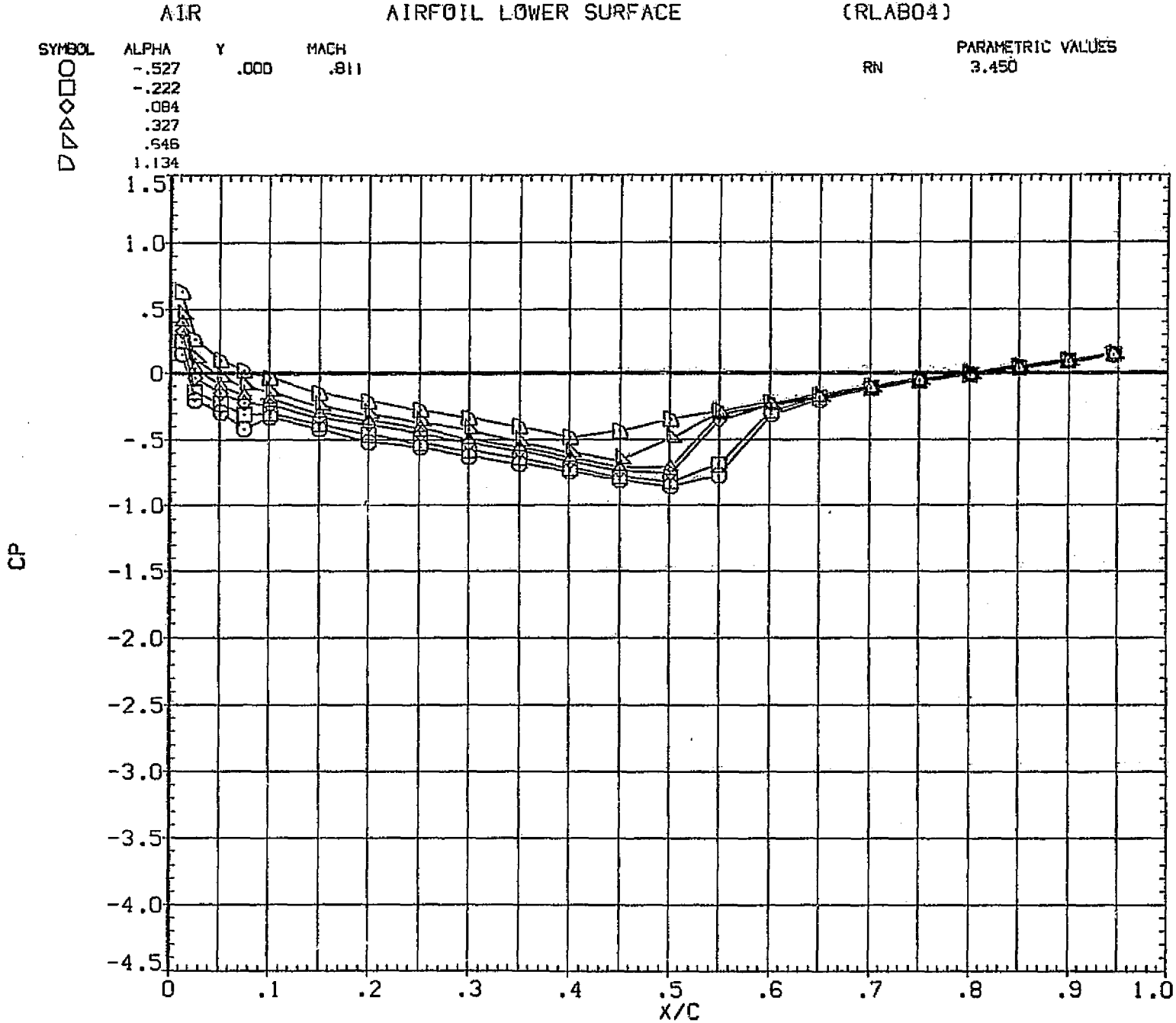

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

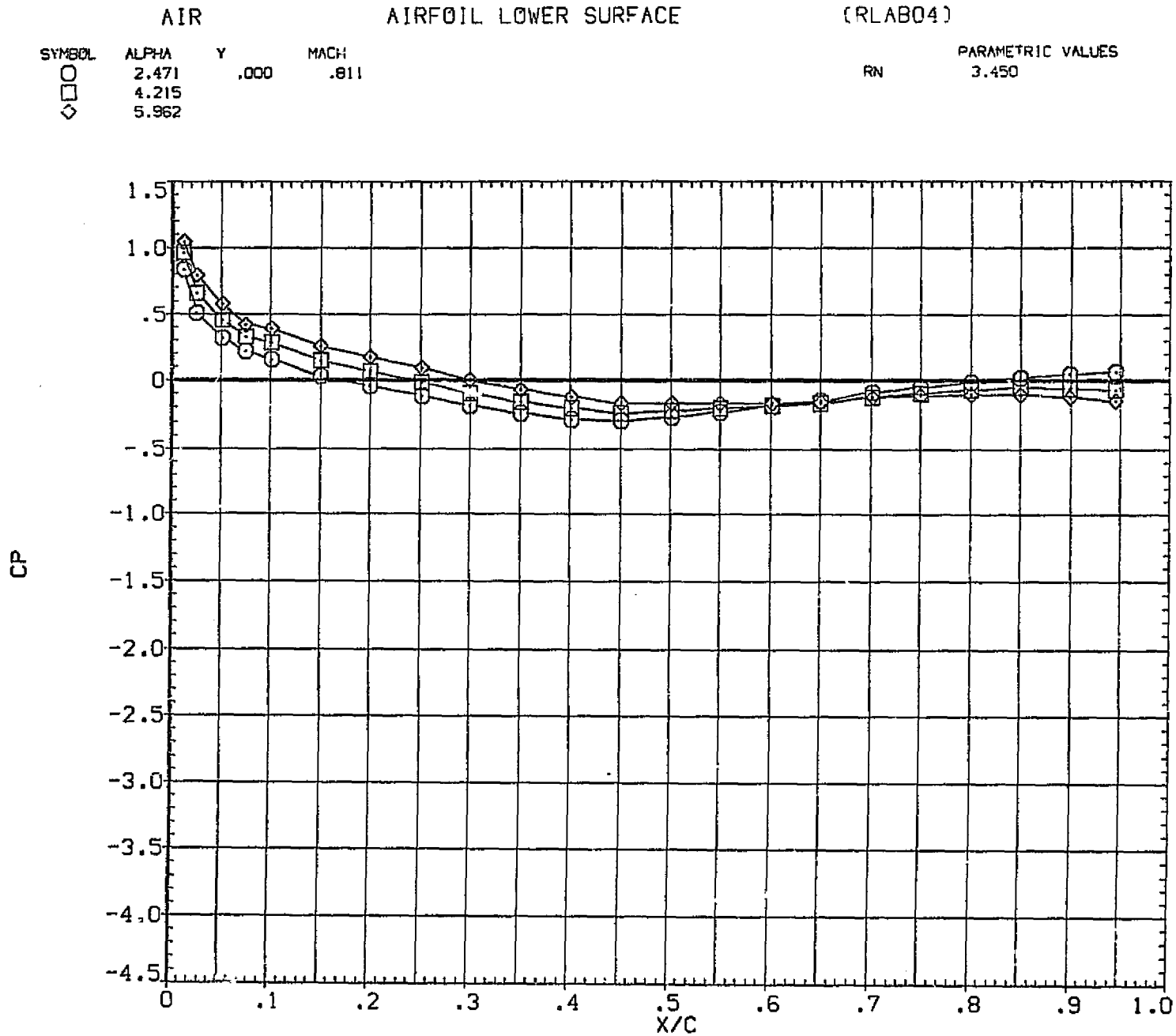

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

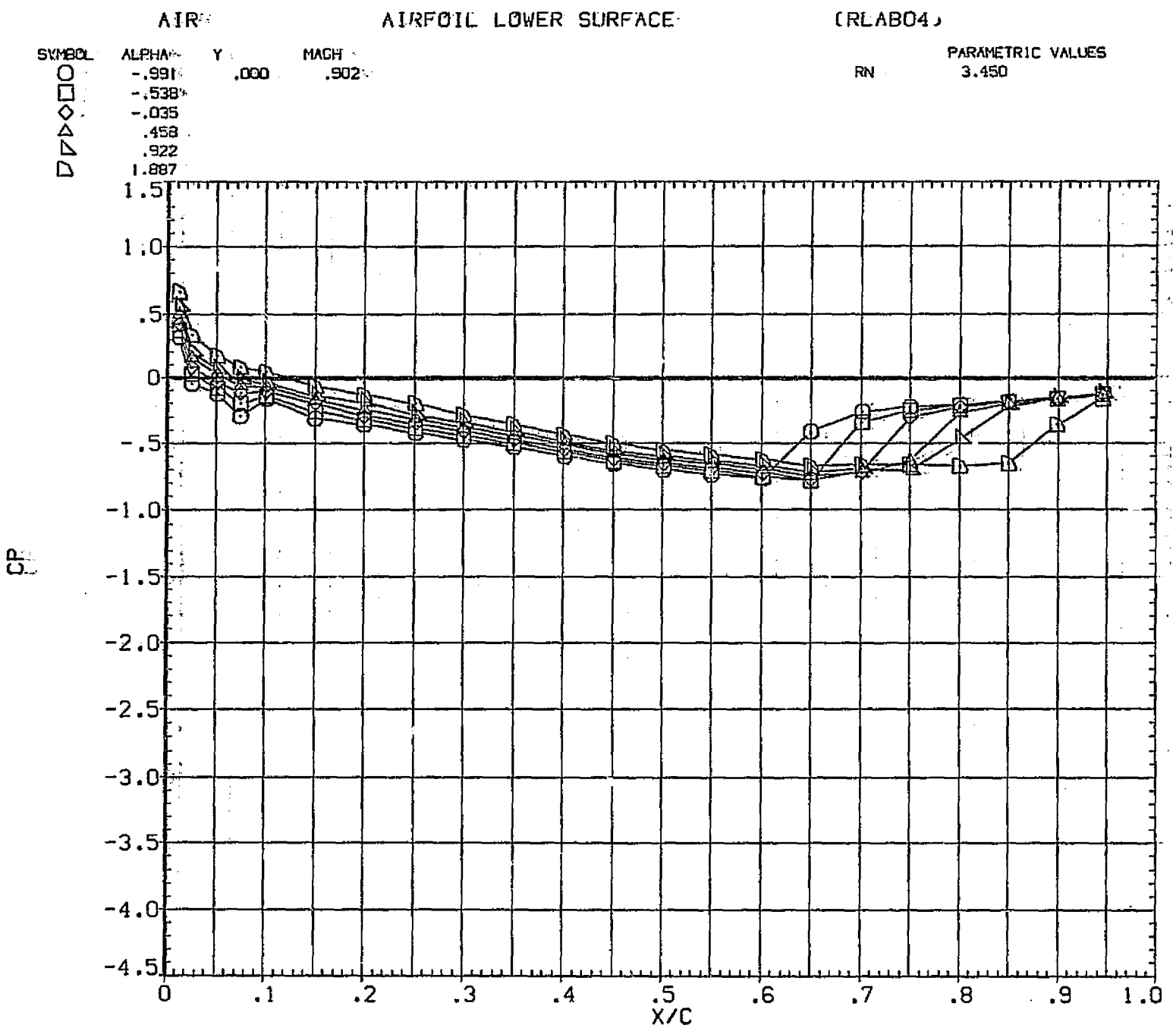

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL LOWER SURFACE (RLAB04)

SYMBOL	ALPHA	Y	MACH
○	3.432	.000	.902
□	4.978		

PARAMETRIC VALUES

RN 3.450

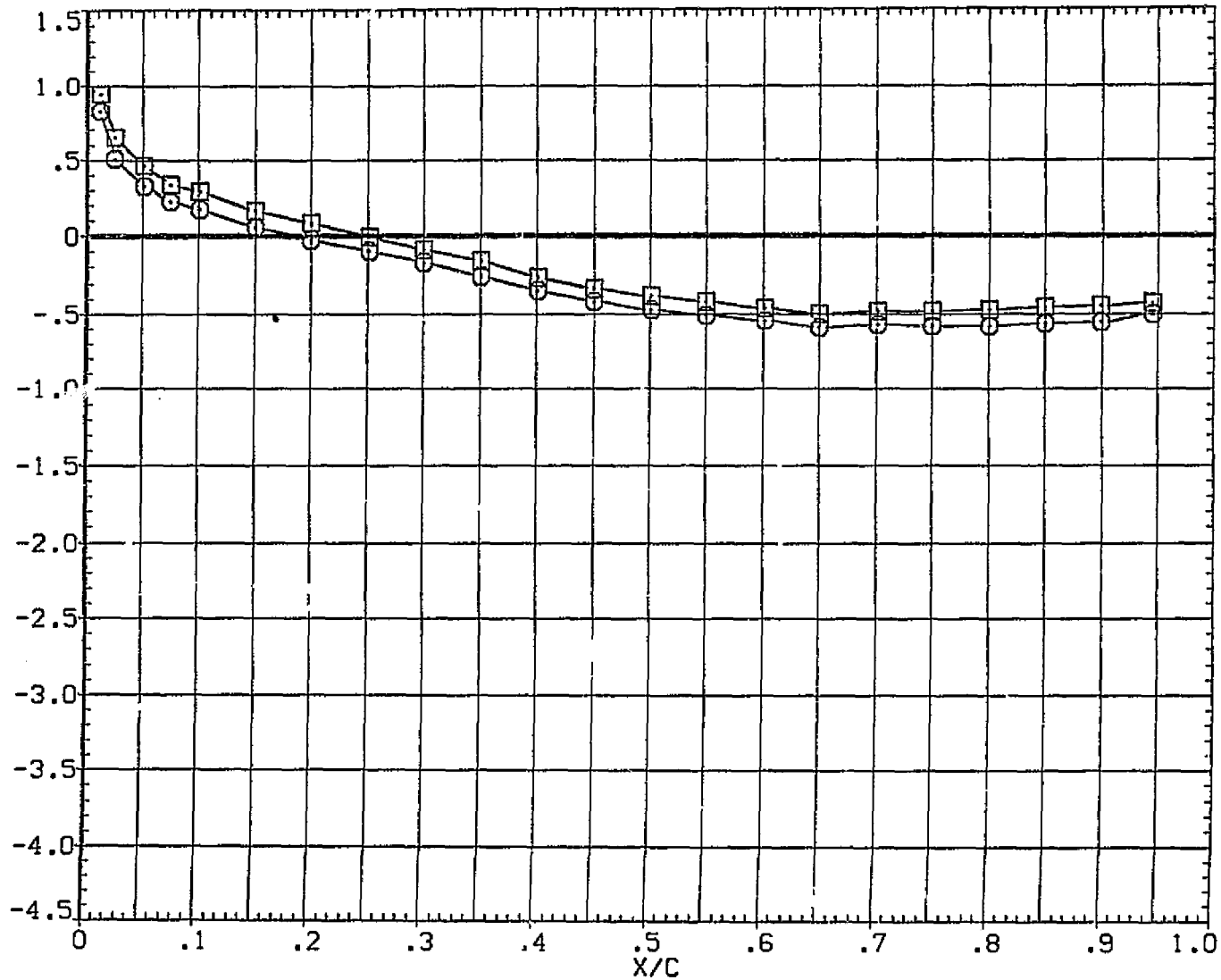

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

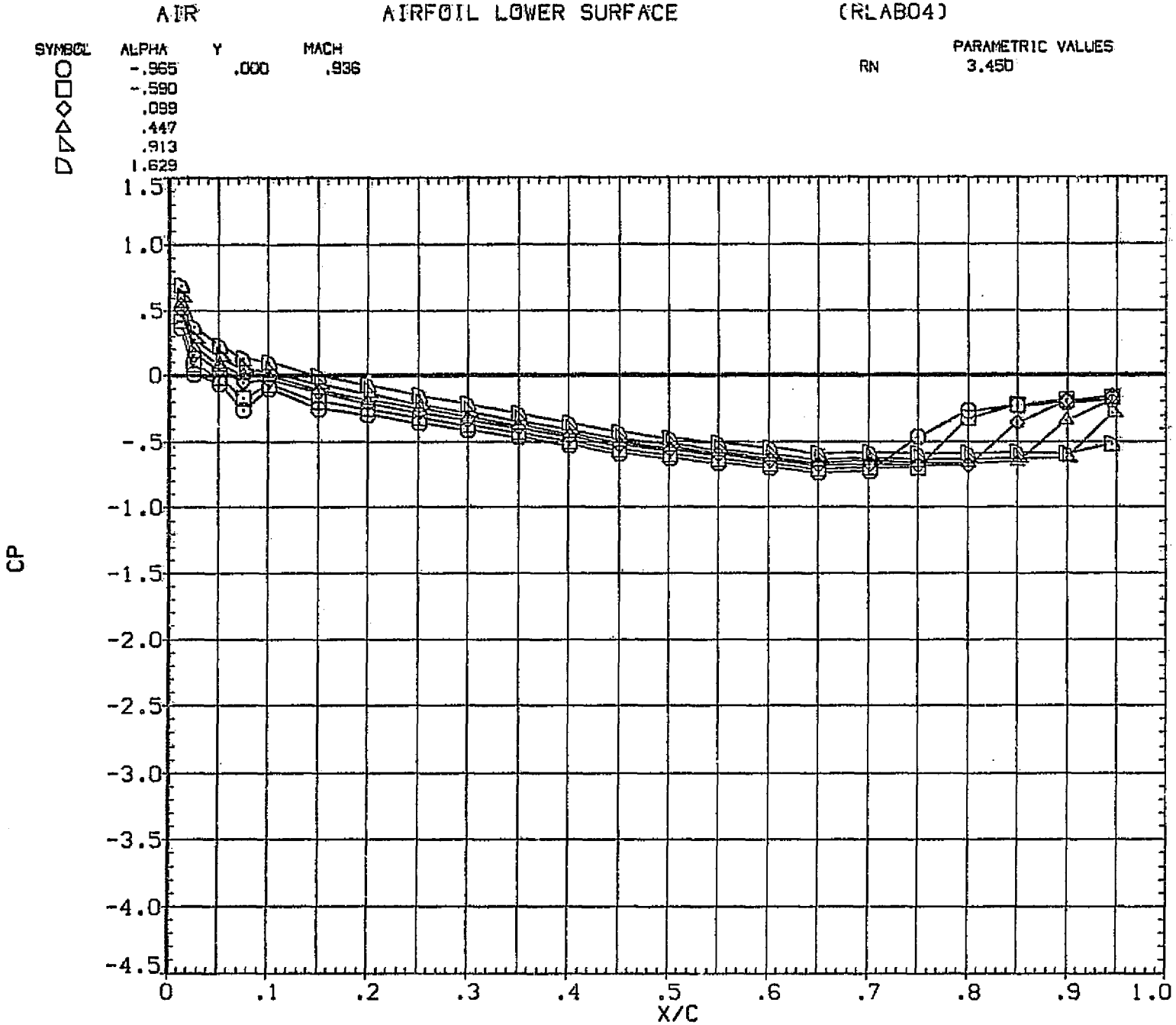

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL LOWER SURFACE (RLAB04)

SYMBOL	ALPHA	Y	MACH
○	3.175	.000	.936
□	4.775		

PARAMETRIC VALUES

RN 3.450

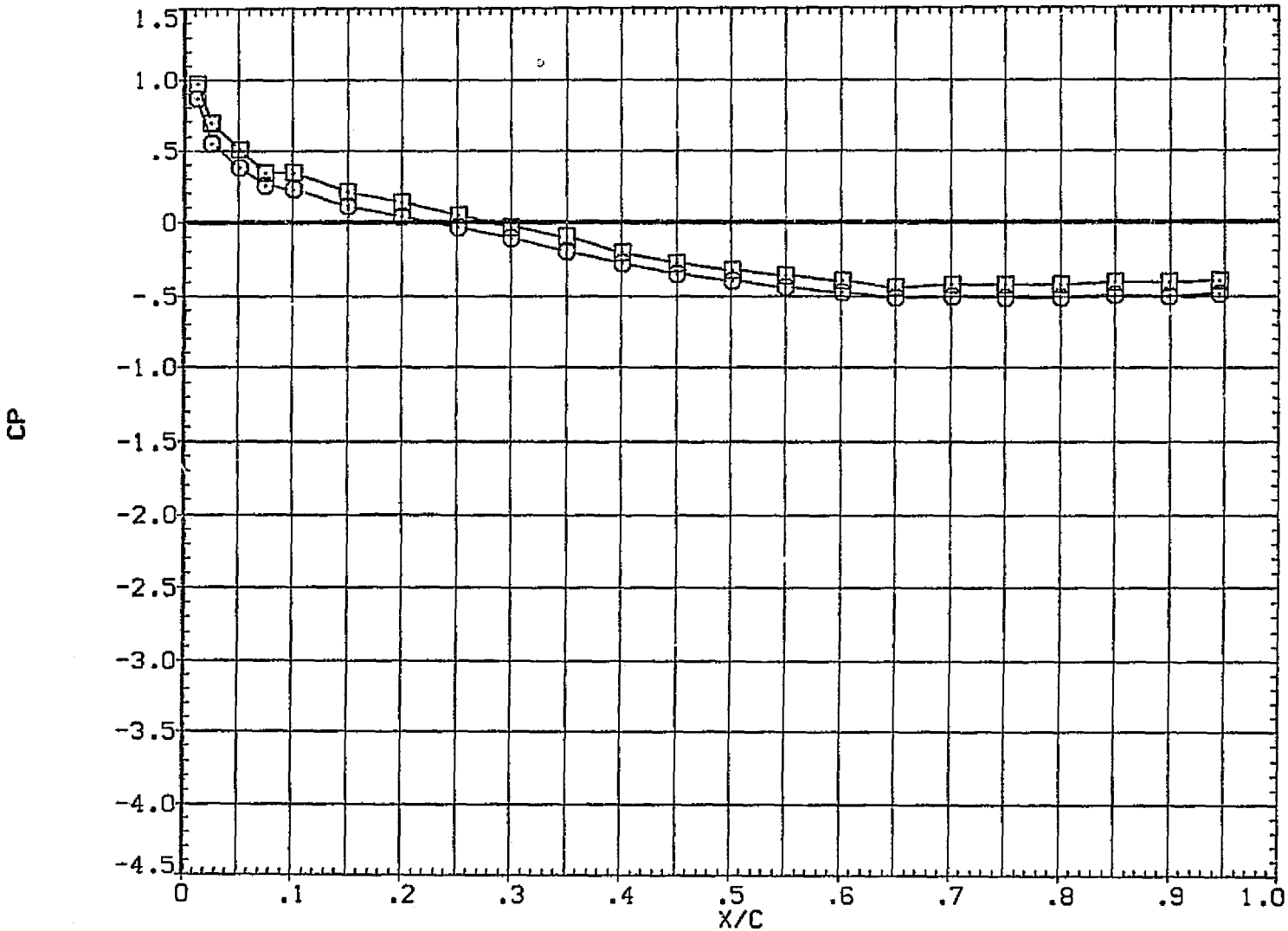

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

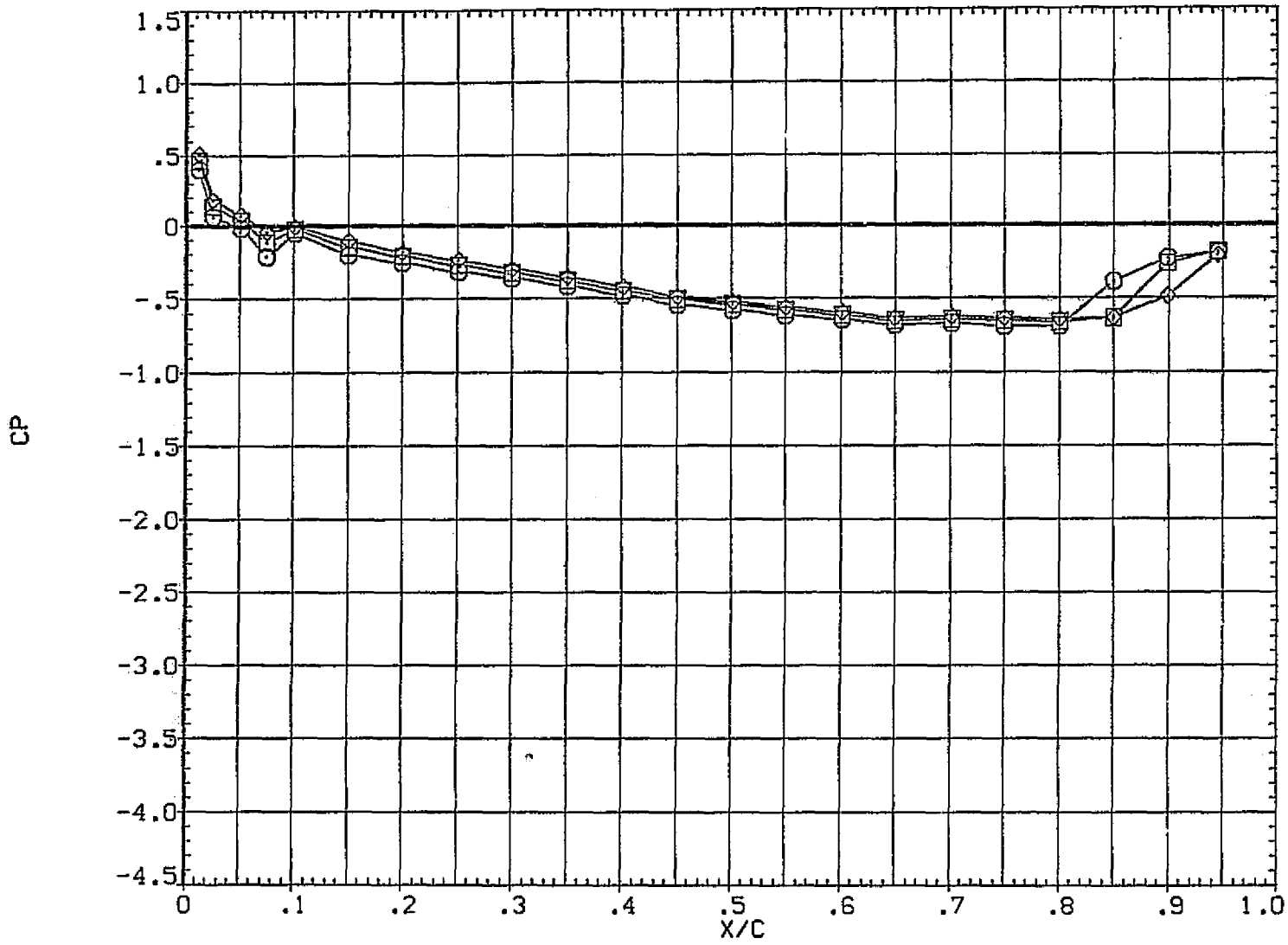

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

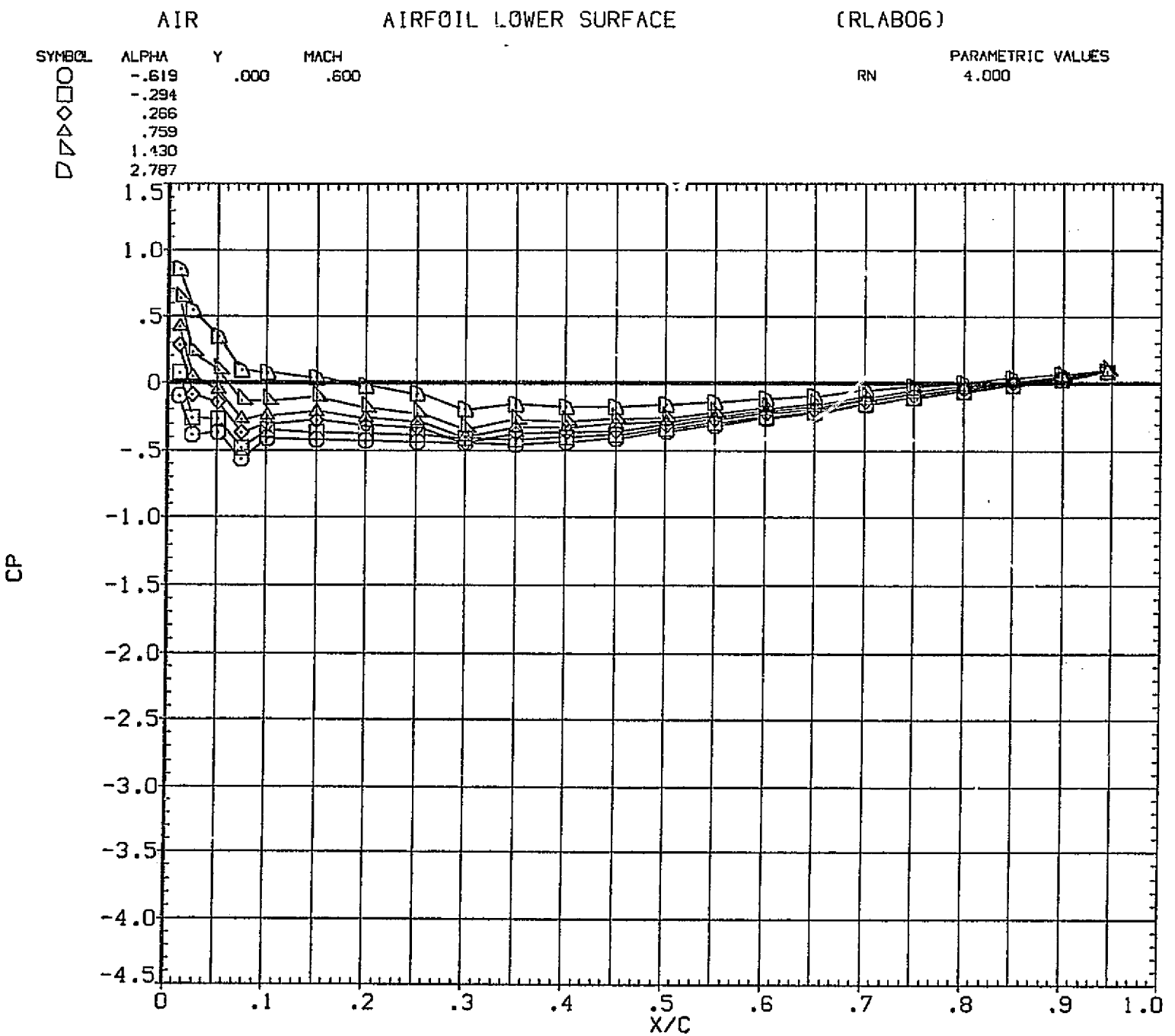

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

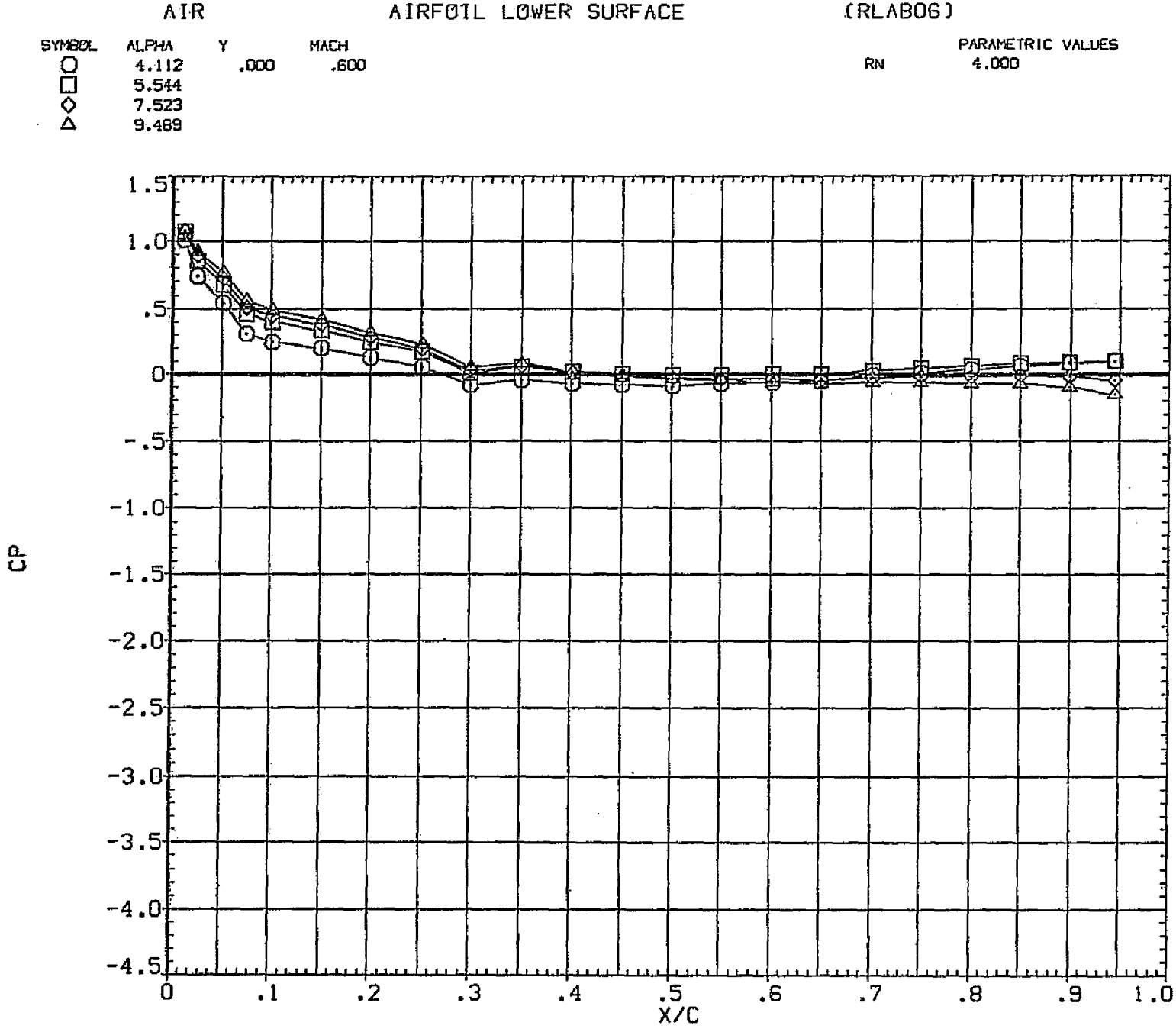

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

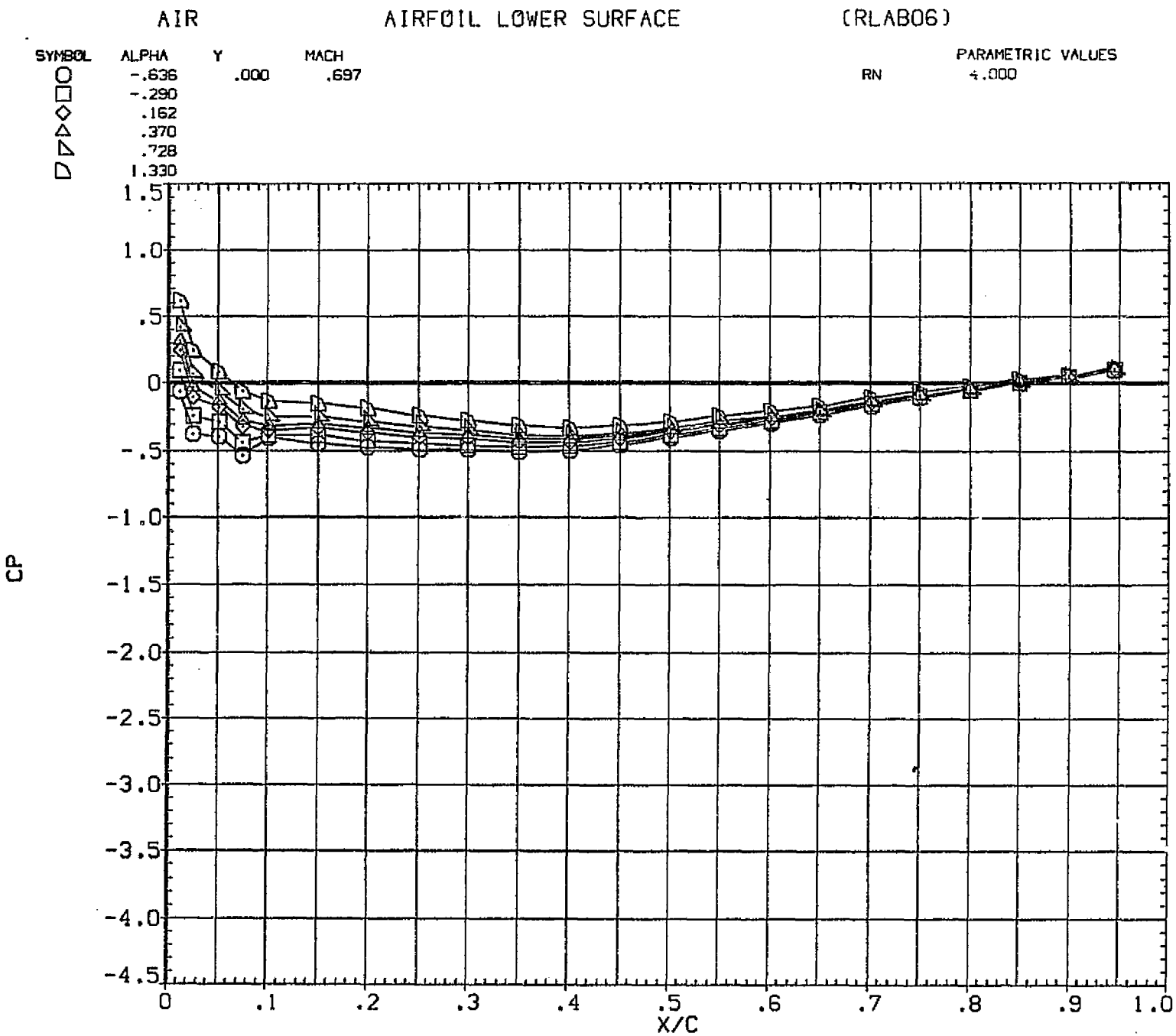

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

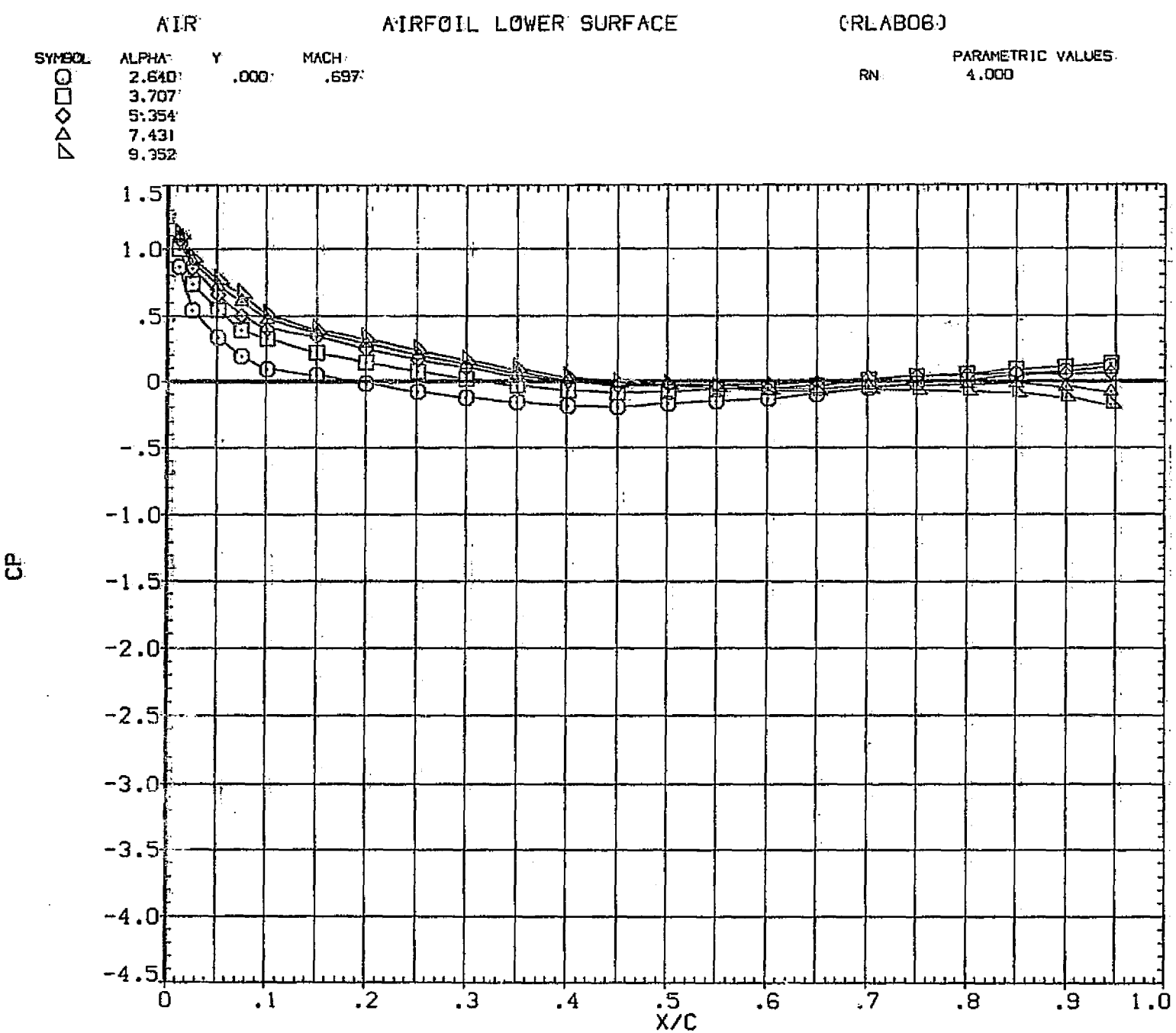

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

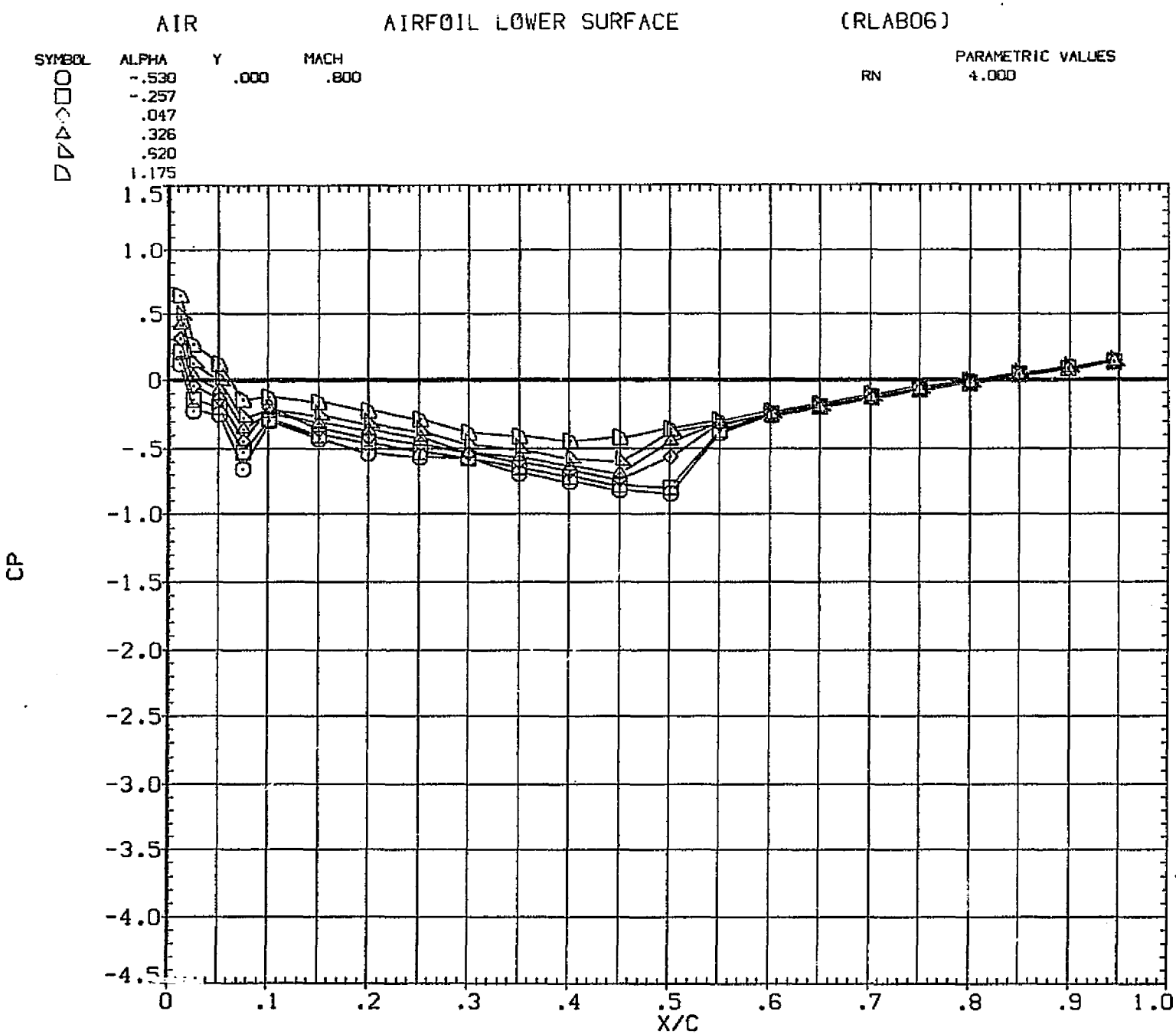

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL LOWER SURFACE (RLAB06)

SYMBOL	ALPHA	Y	MACH
O	2.402	.000	.800

PARAMETRIC VALUES
RN 4.000

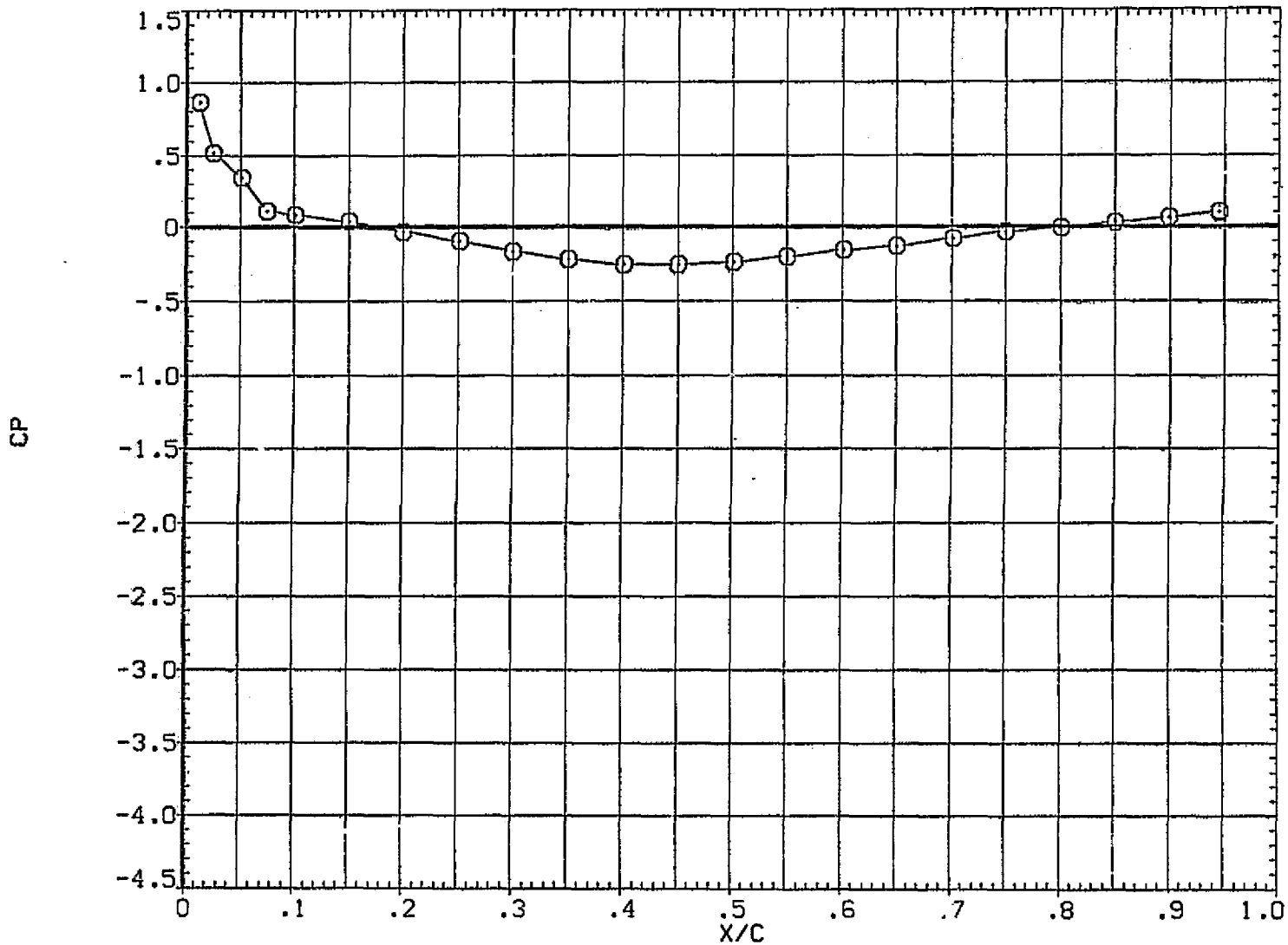

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

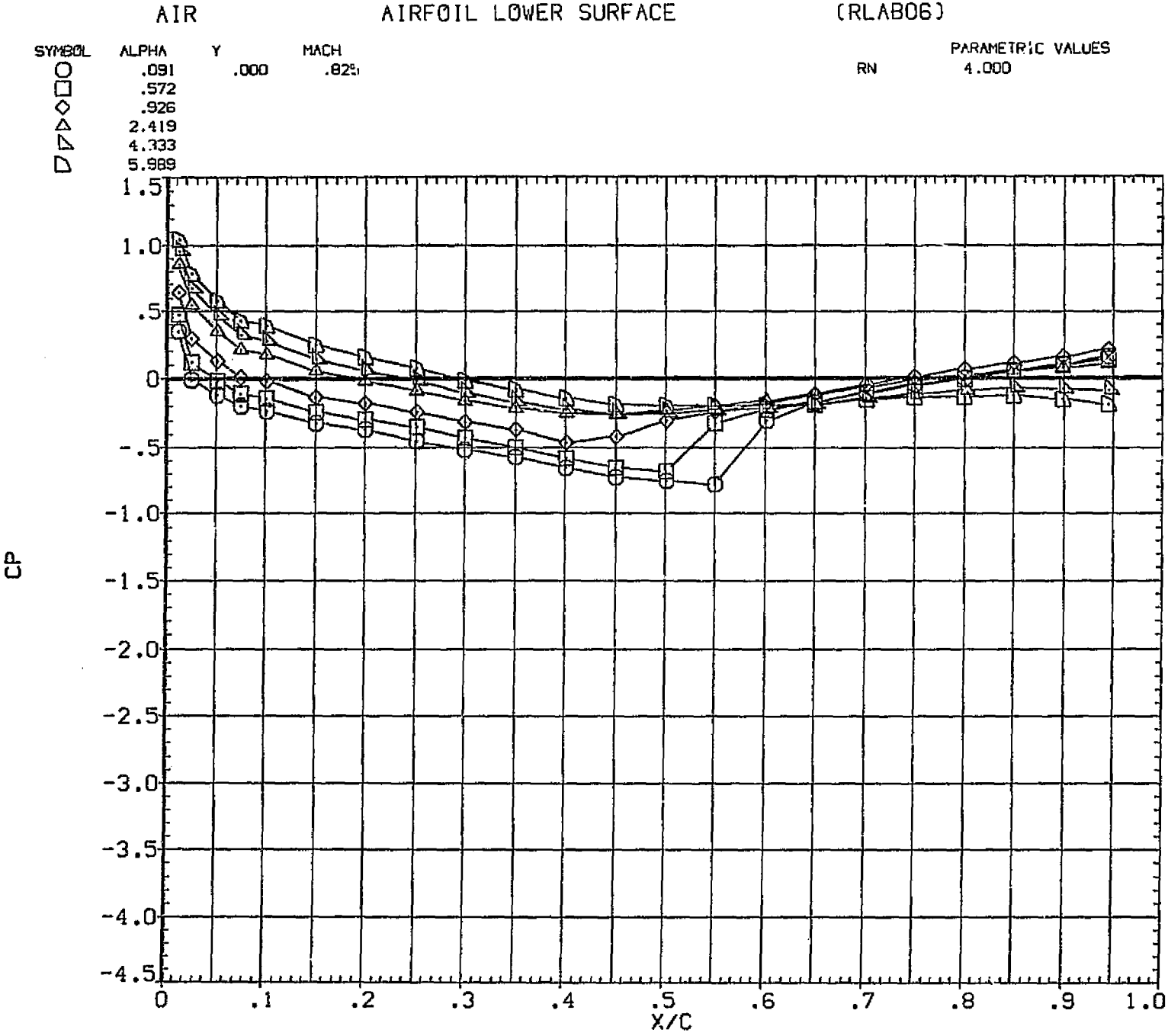

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

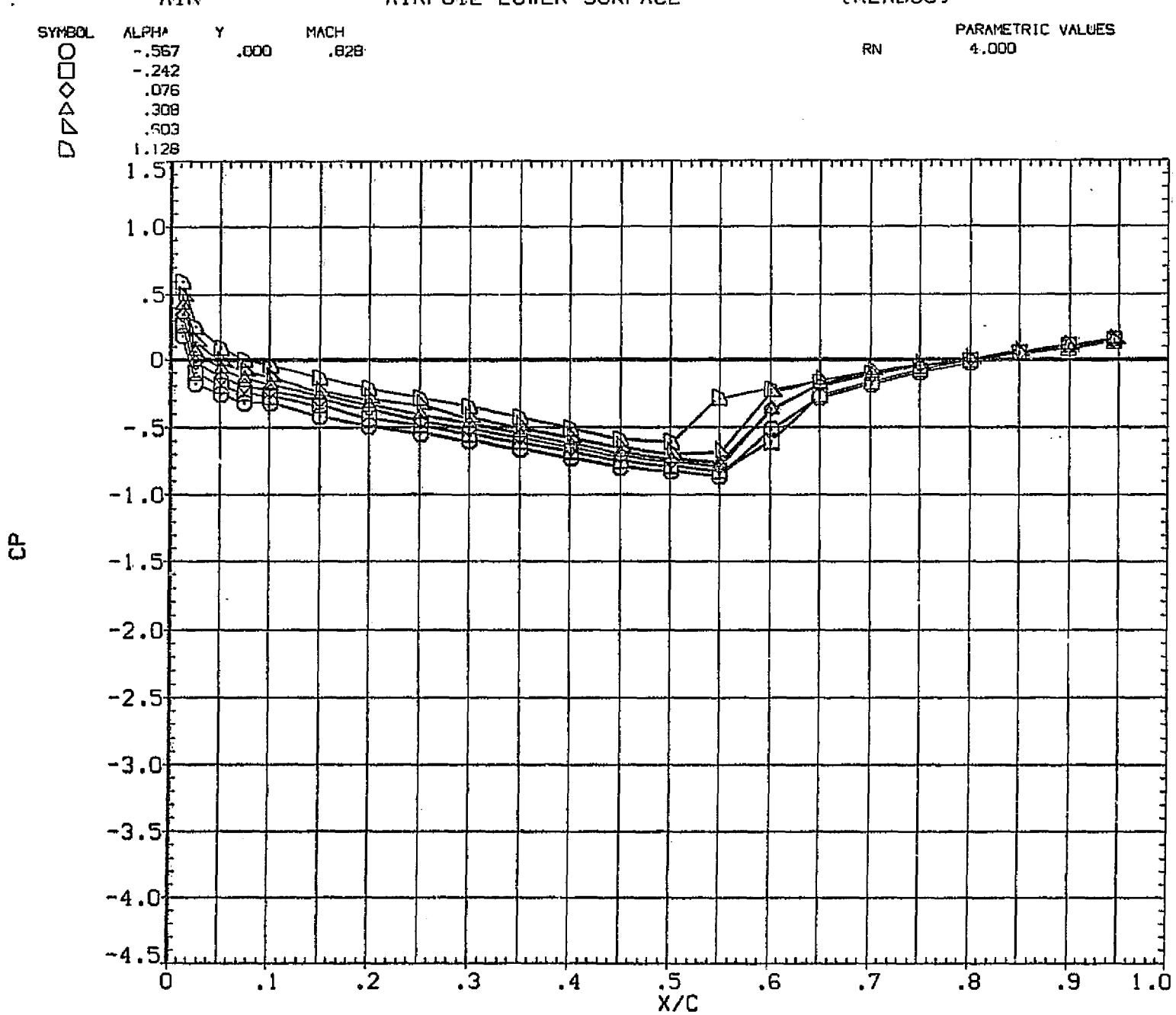

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

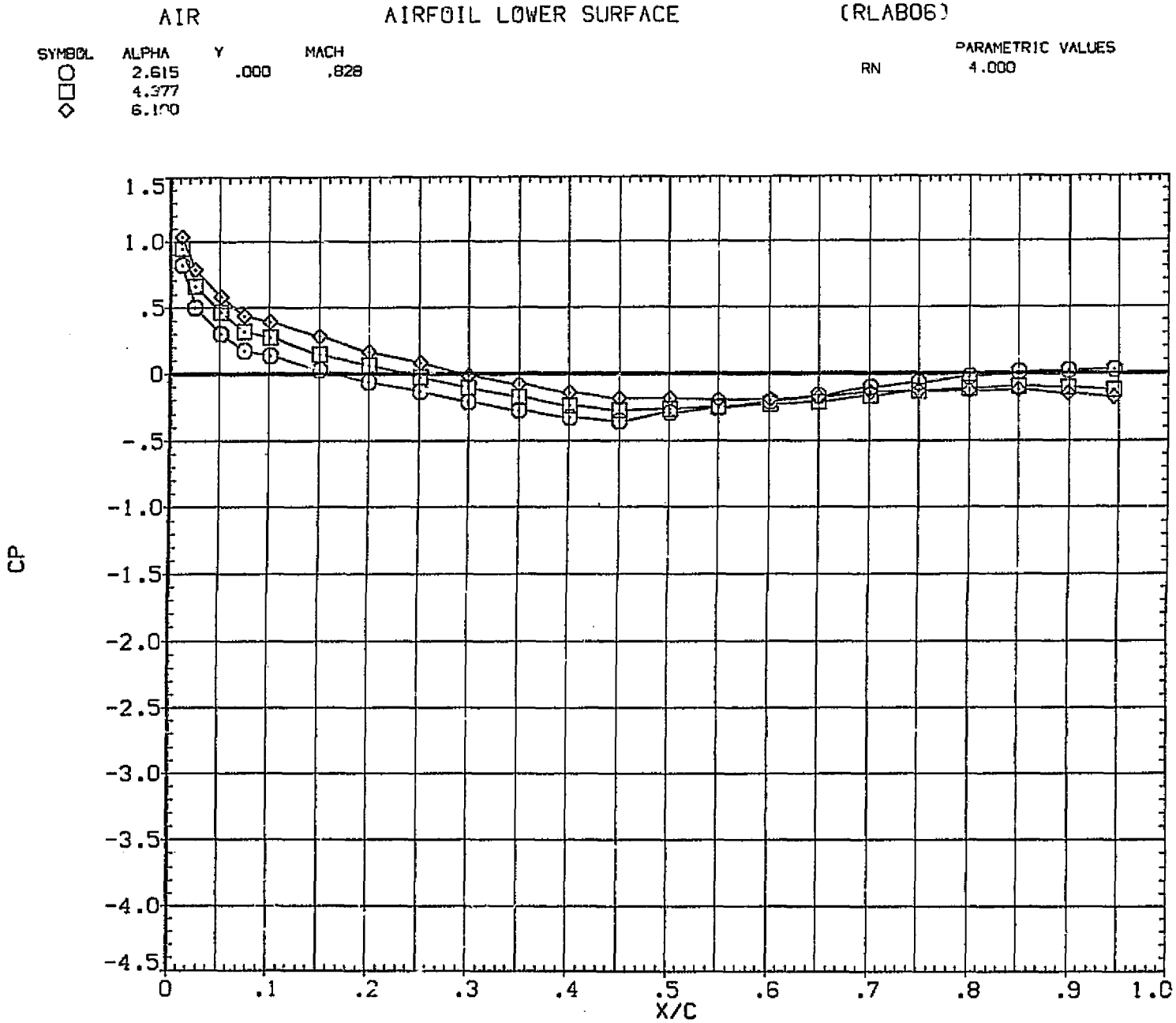

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

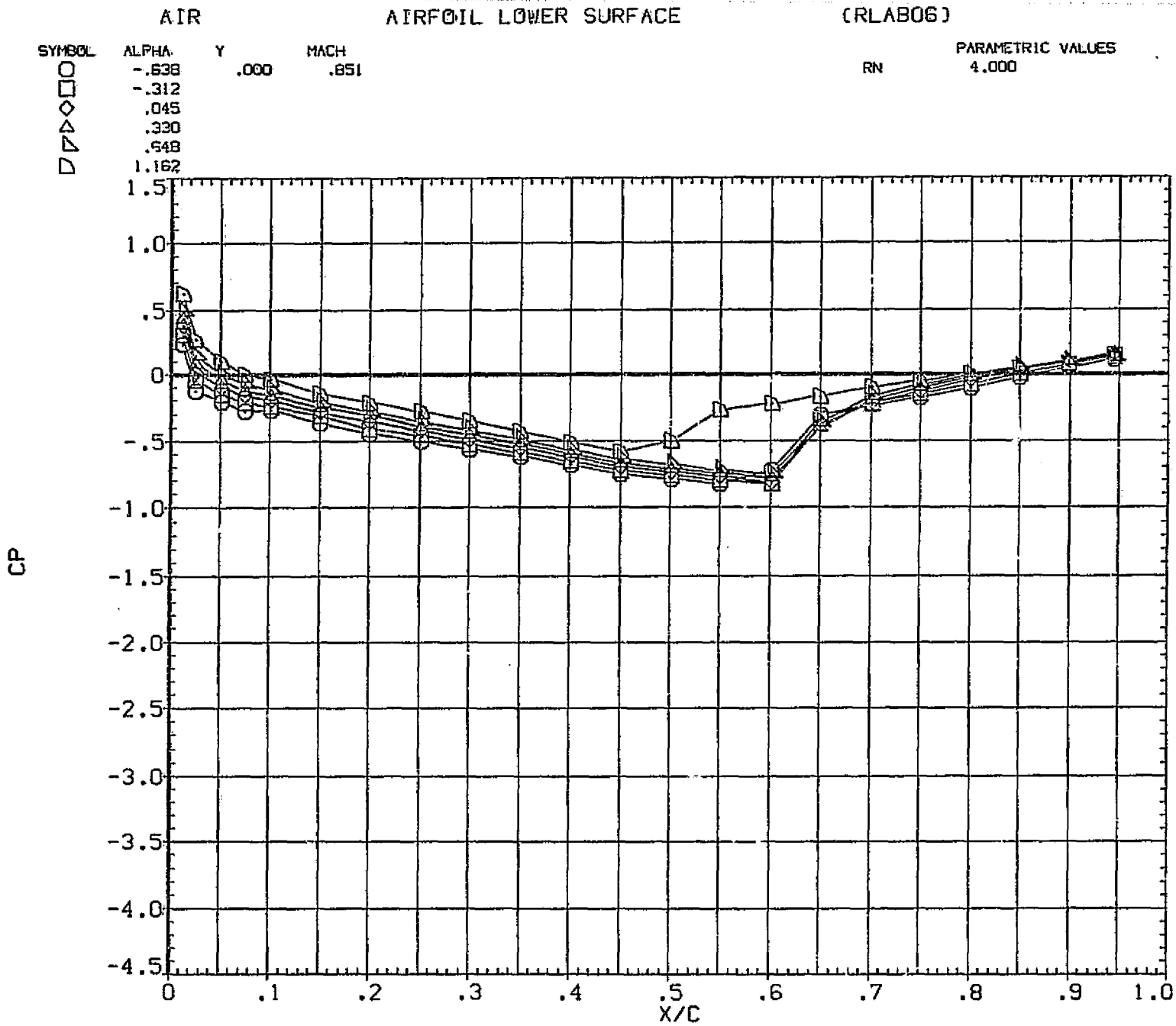

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

AIR AIRFOIL LOWER SURFACE (RLAB06)

SYMBOL	ALPHA	Y	MACH
○	2.917	.000	.851
□	4.511		

PARAMETRIC VALUES

RN 4.000

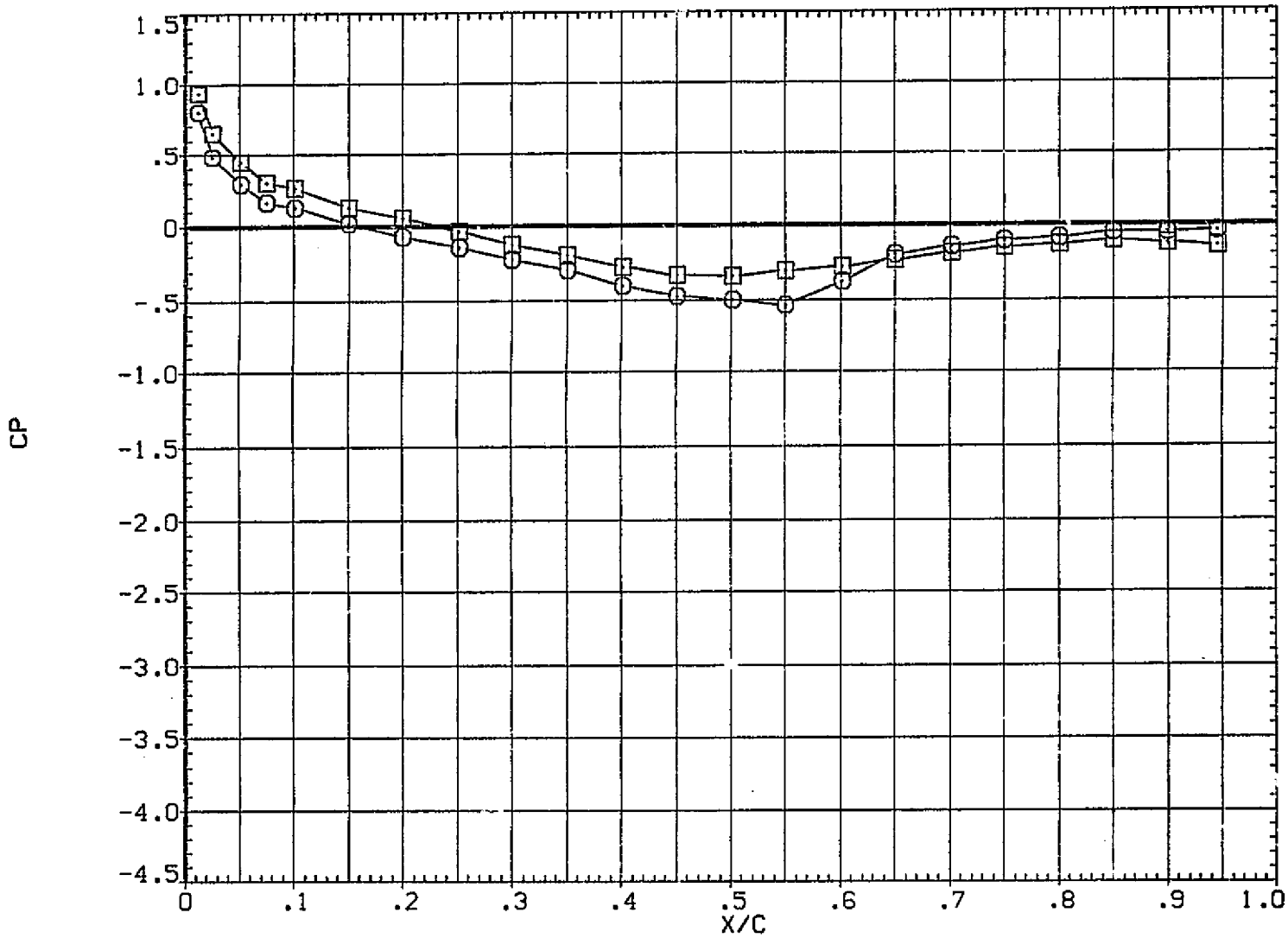

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

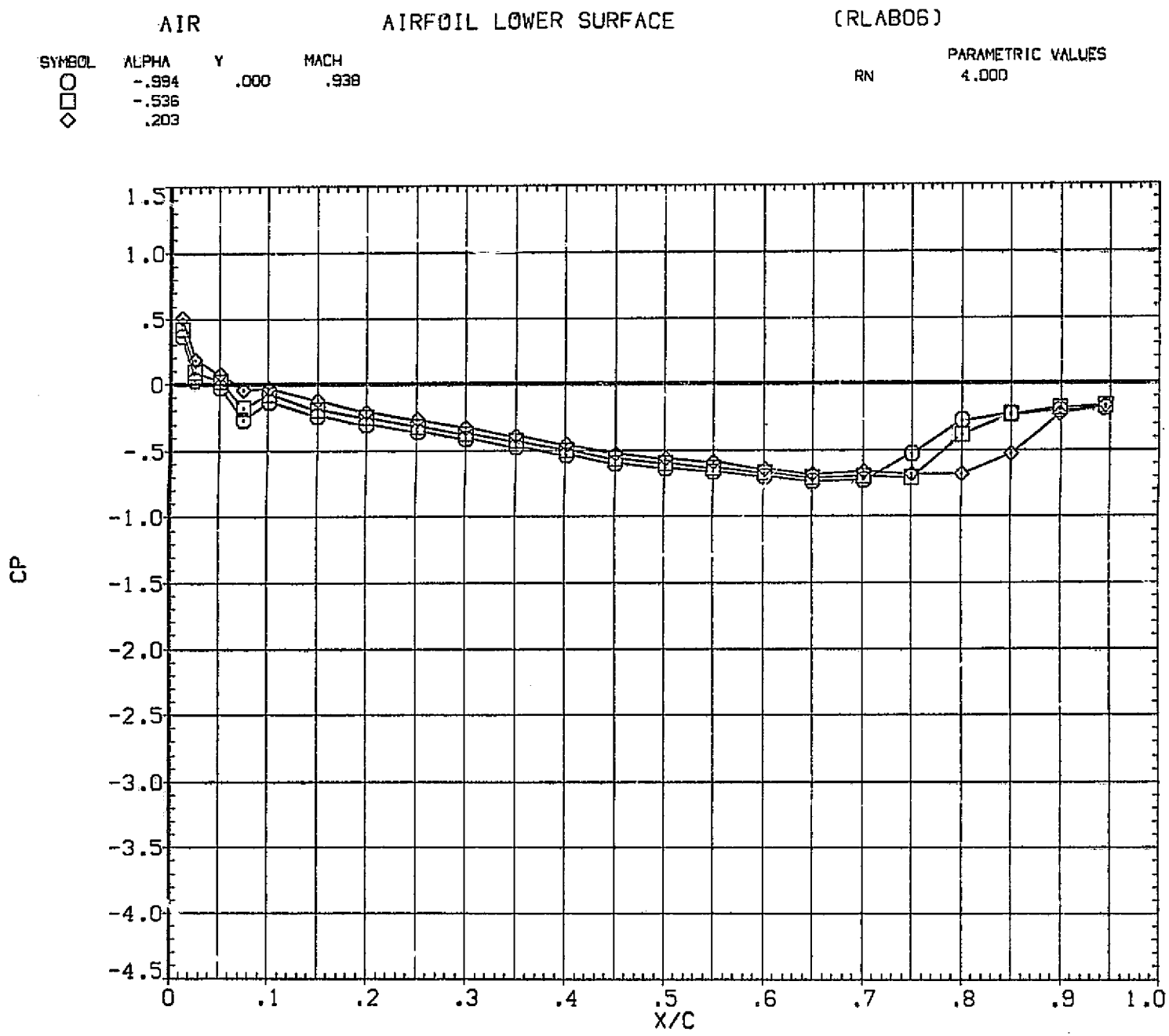

FIG. 3 BASIC DATA, PRESSURE DISTRIBUTIONS IN AIR

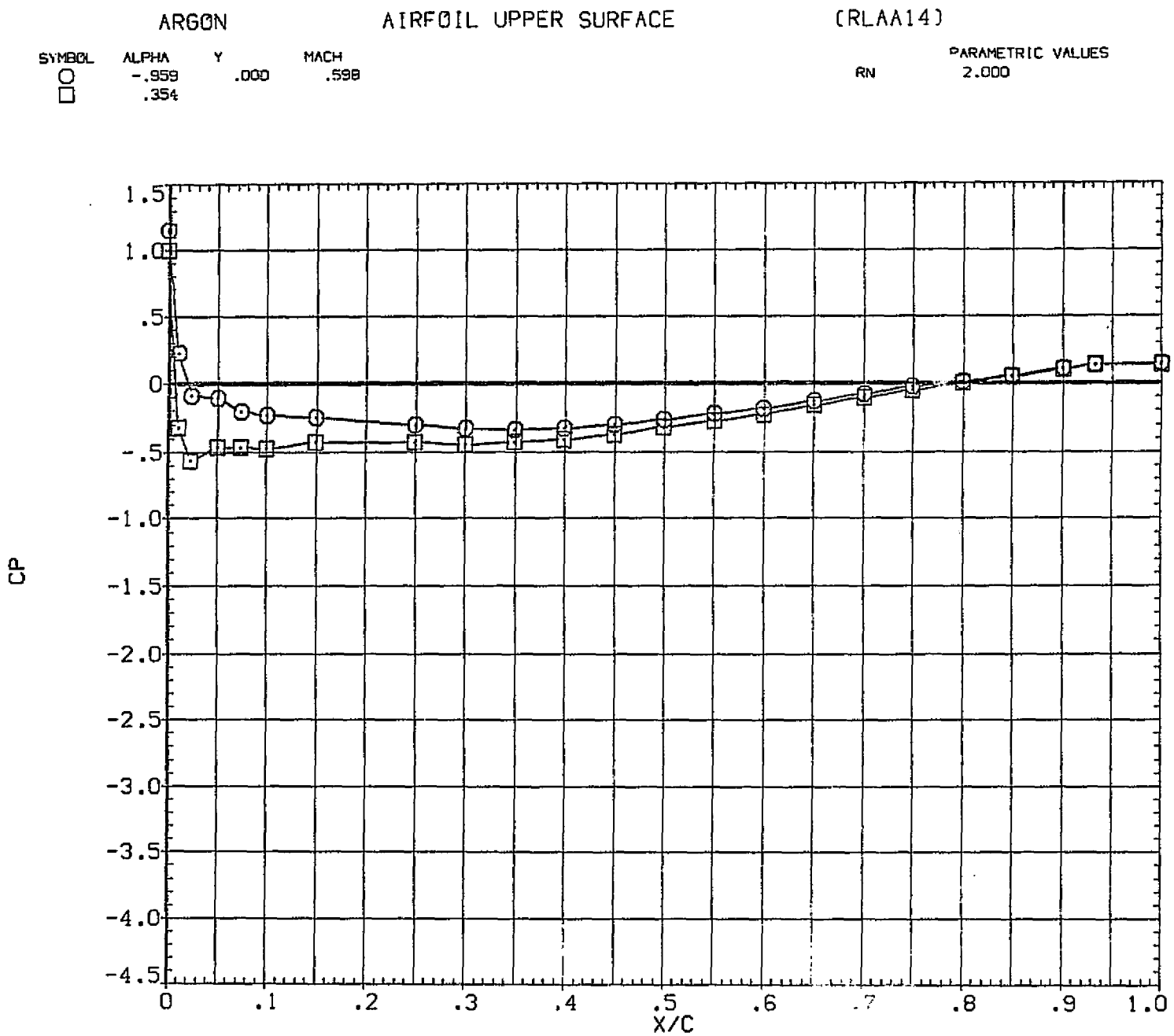

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

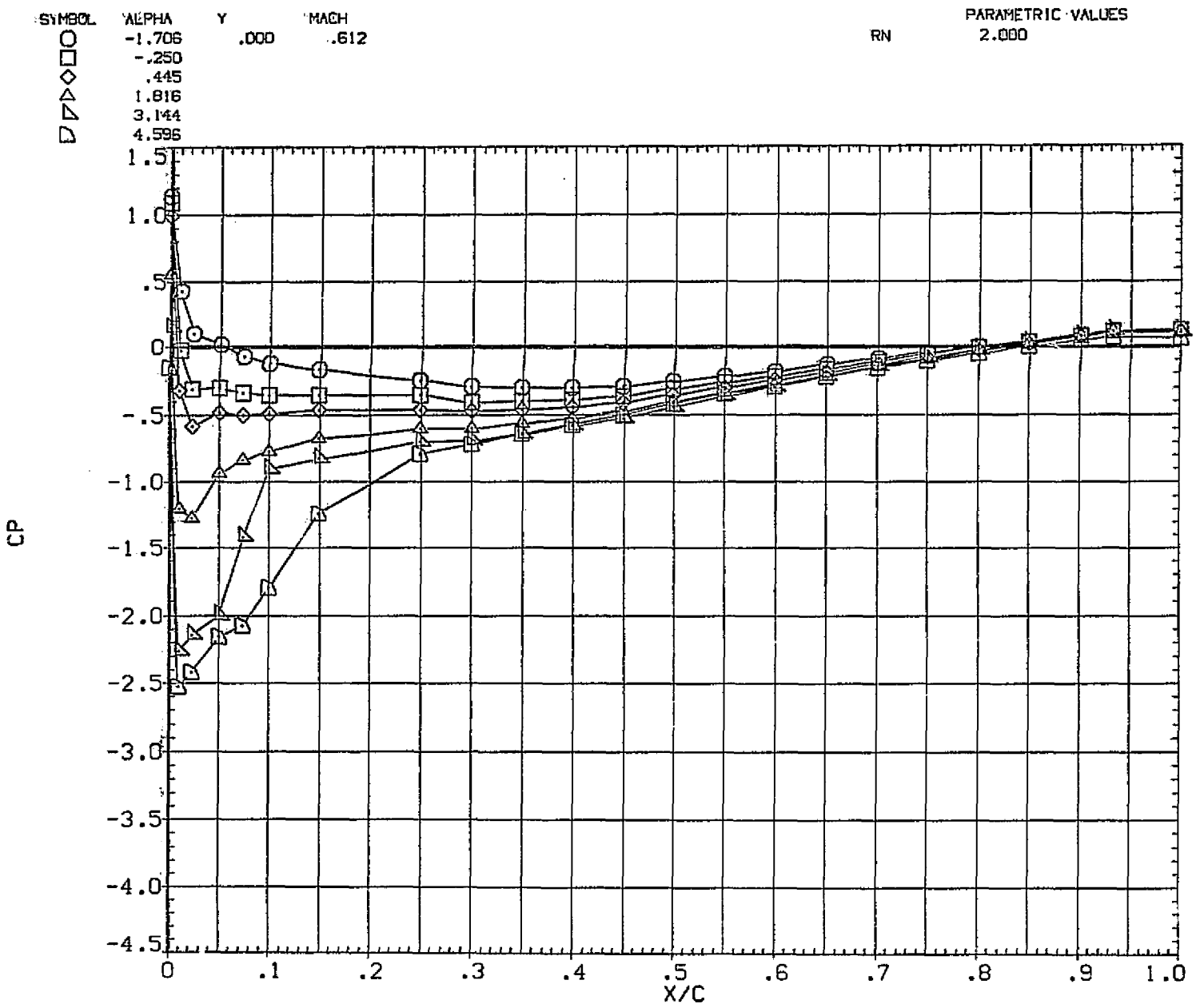

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

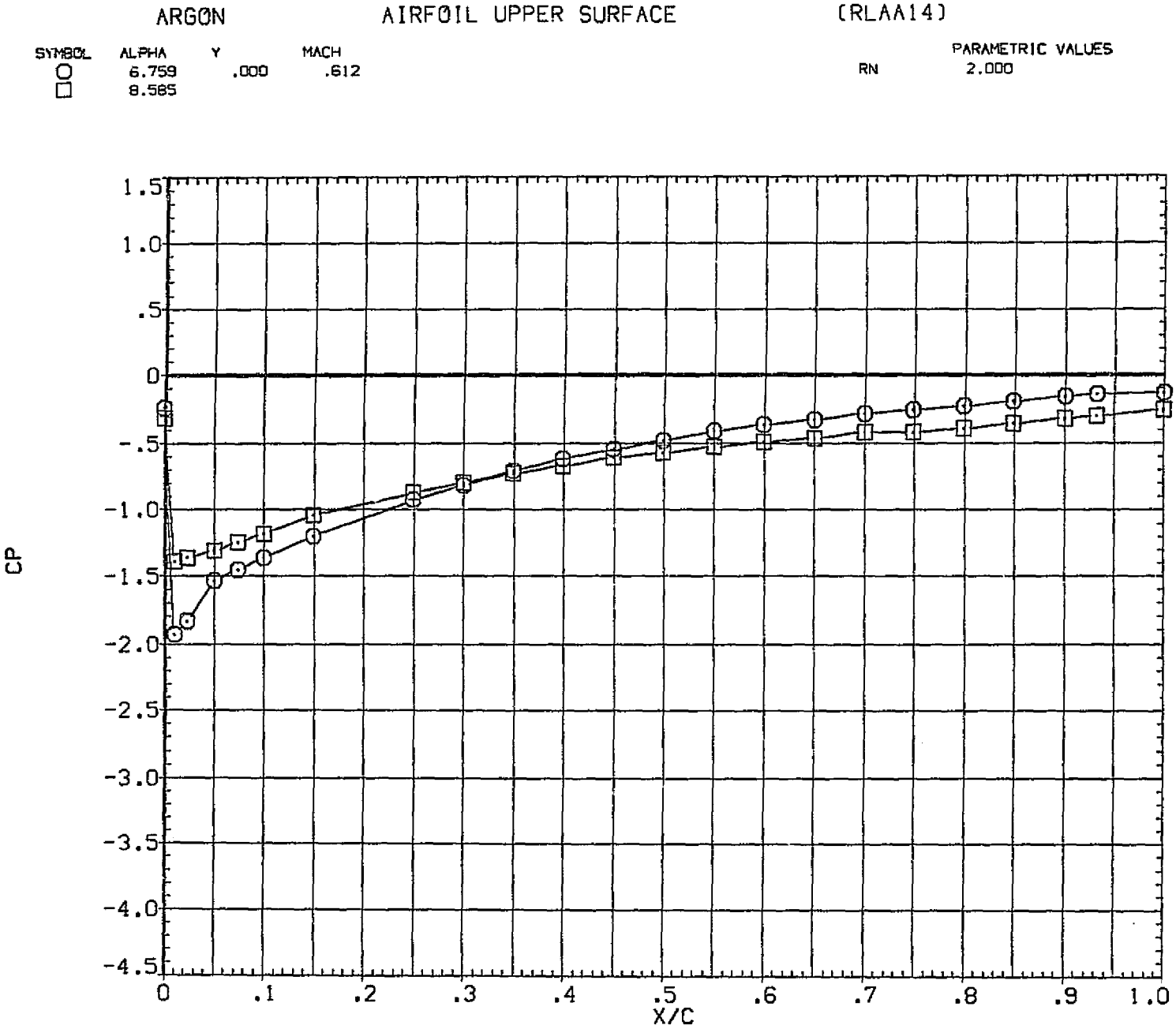

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

ARGØN AIRFØIL UPPER SURFACE (RLAA14)

SYMBOL	ALPHA	Y	MACH
○	-.942	.000	.816
□	.136		

PARAMETRIC VALUES

RN 2.000

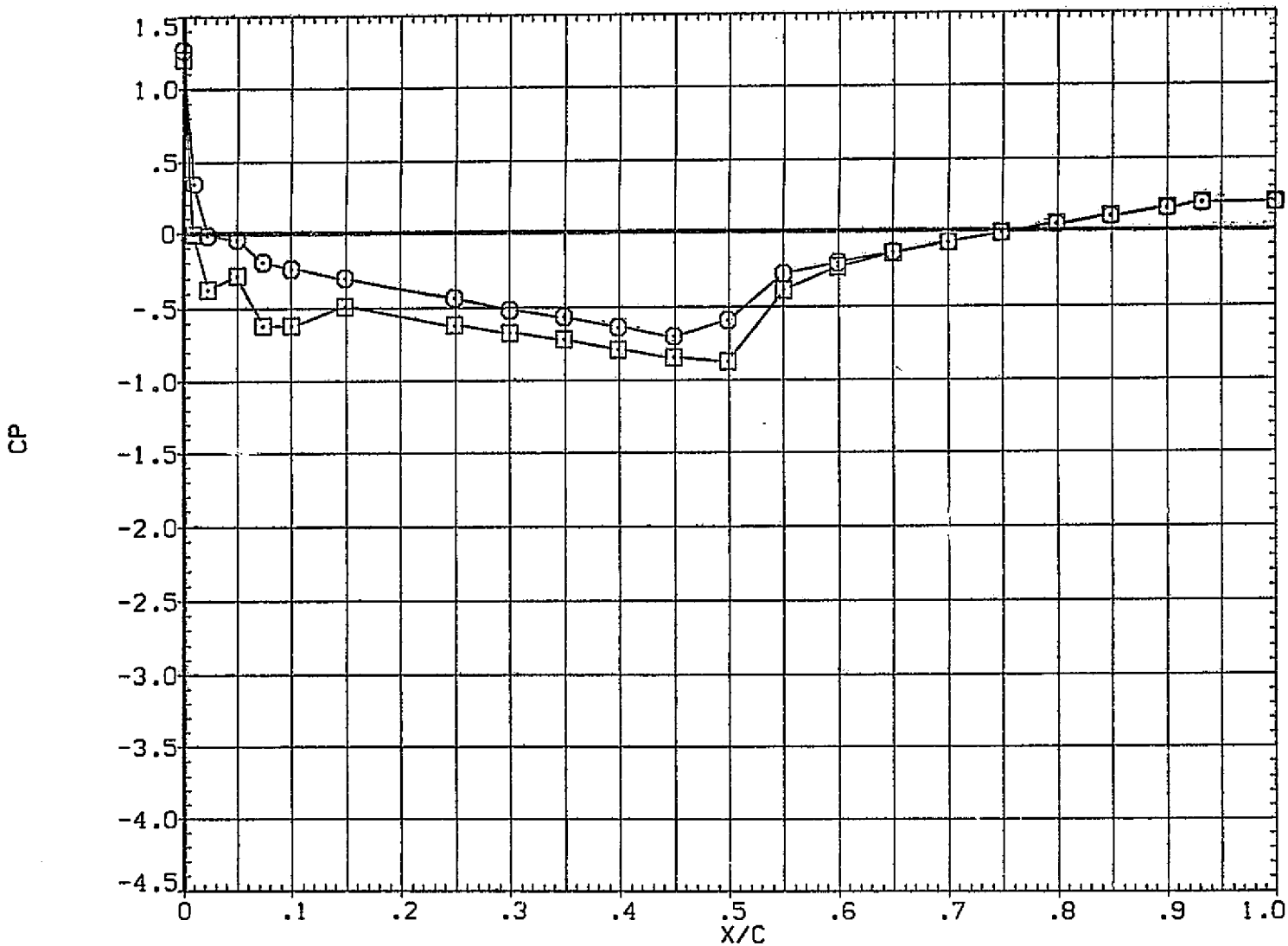

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIØNS IN ARGØN

ARGON AIRFOIL UPPER SURFACE (RLAA14)

SYMBOL	ALPHA	Y	MACH
○	-.946	.000	.823
□	.152		

PARAMETRIC VALUES

RN 2.000

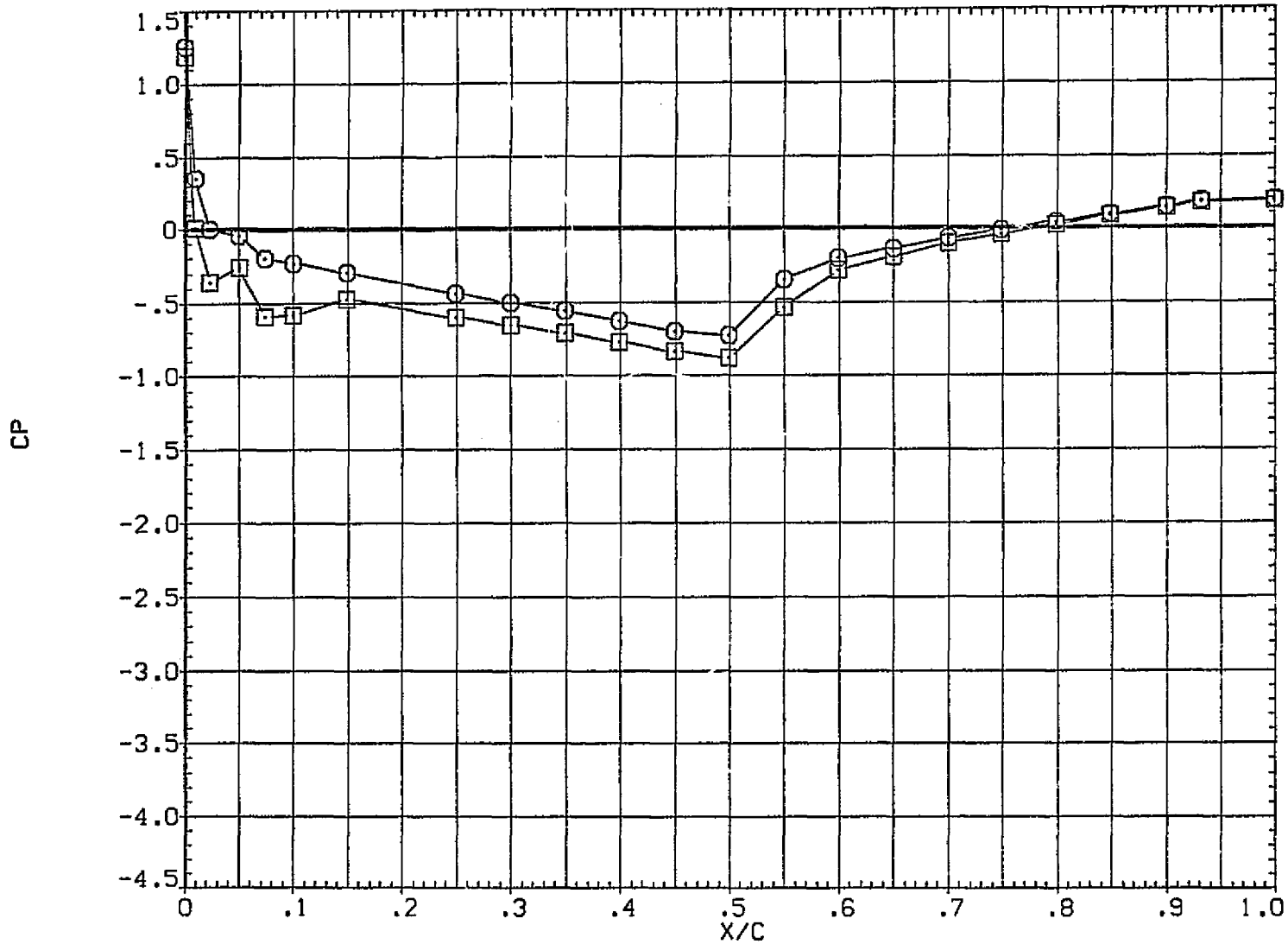

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

SYMBOL	ALPHA	Y	MACH
○	-.966	.000	.839
□	.148		

PARAMETRIC VALUES
RN 2.000

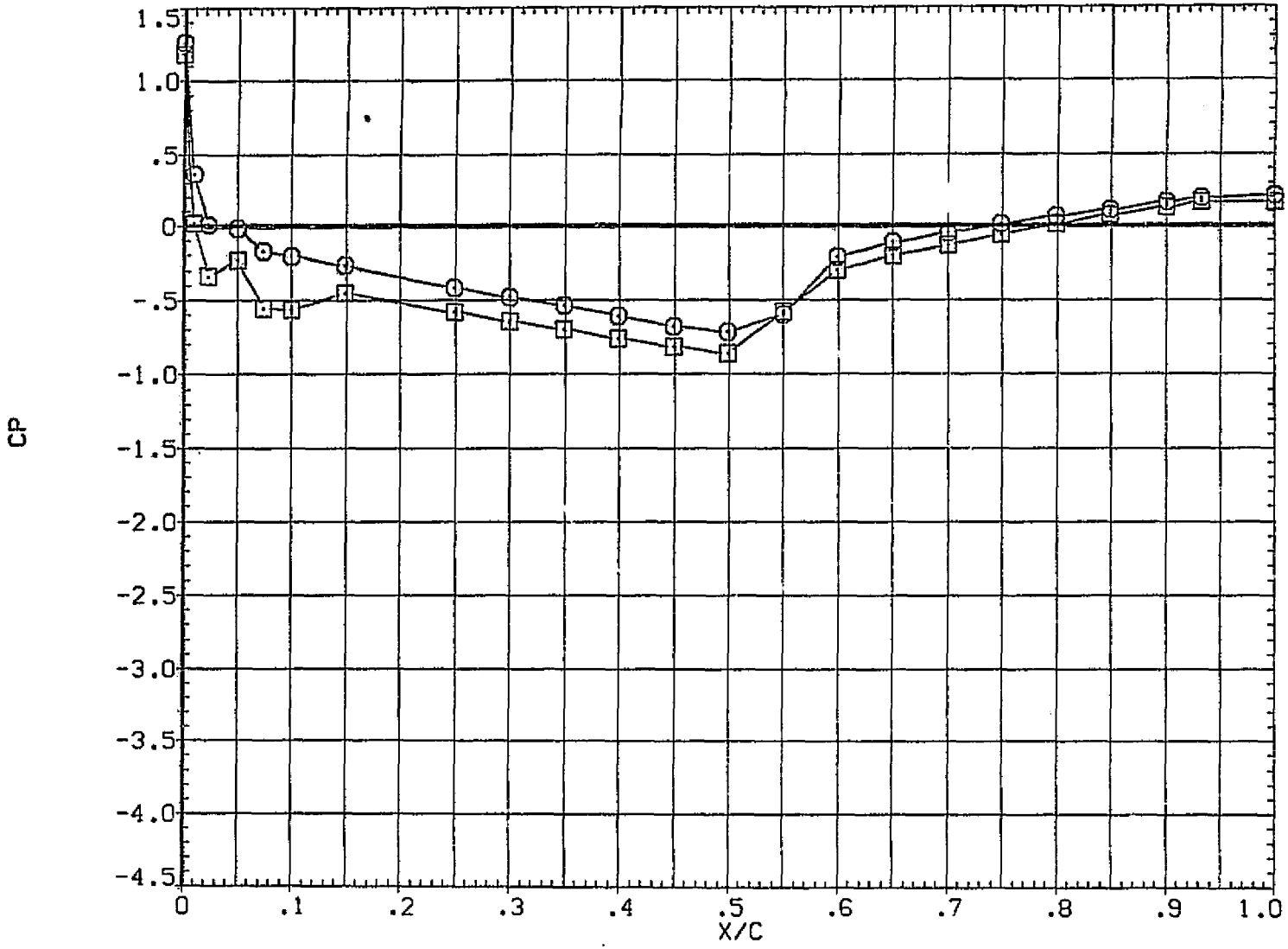

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

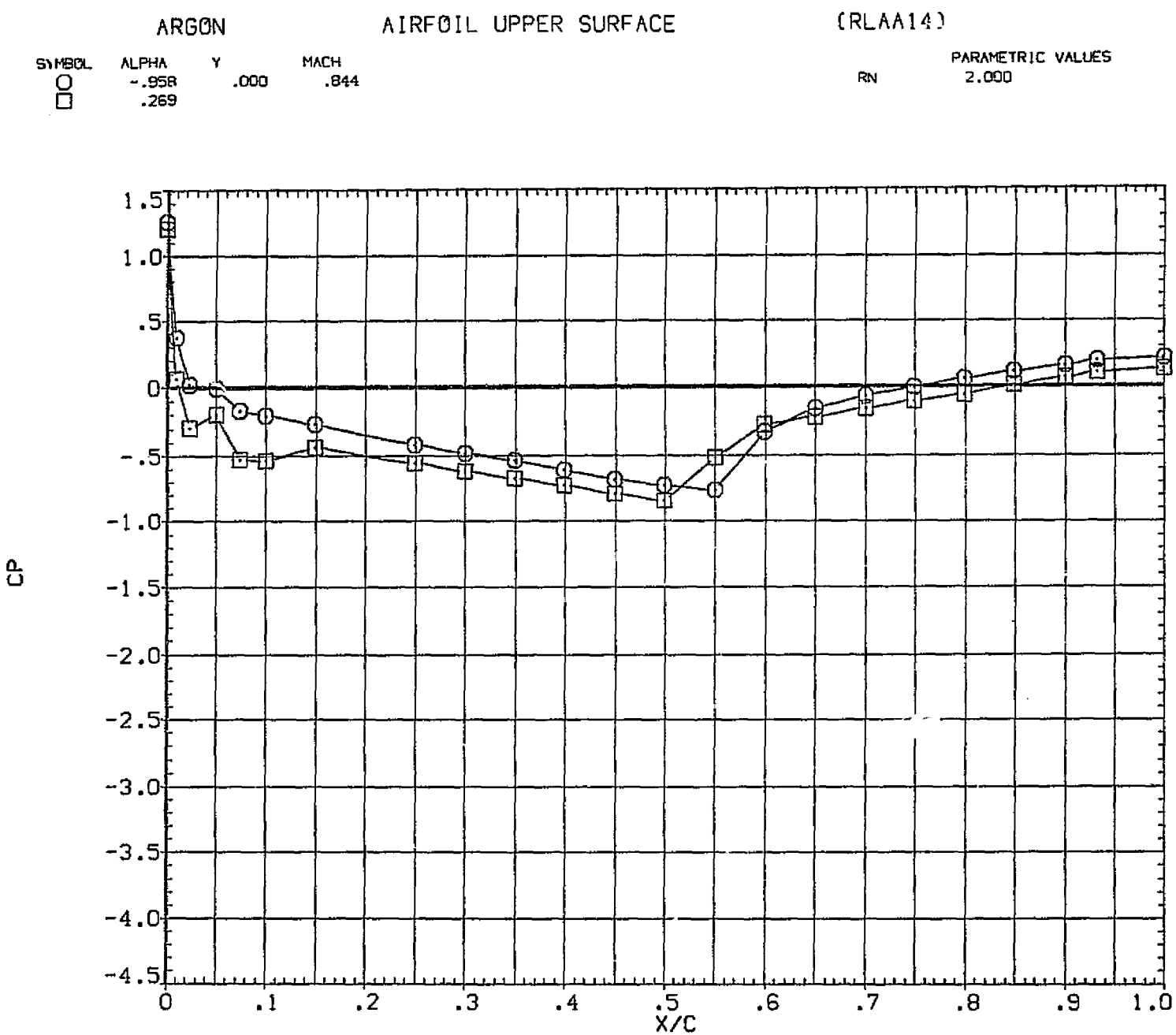

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

SYMBOL	ALPHA	Y	MACH
○	-.984	.000	.868
□	.527		

PARAMETRIC VALUES
RN 2.000

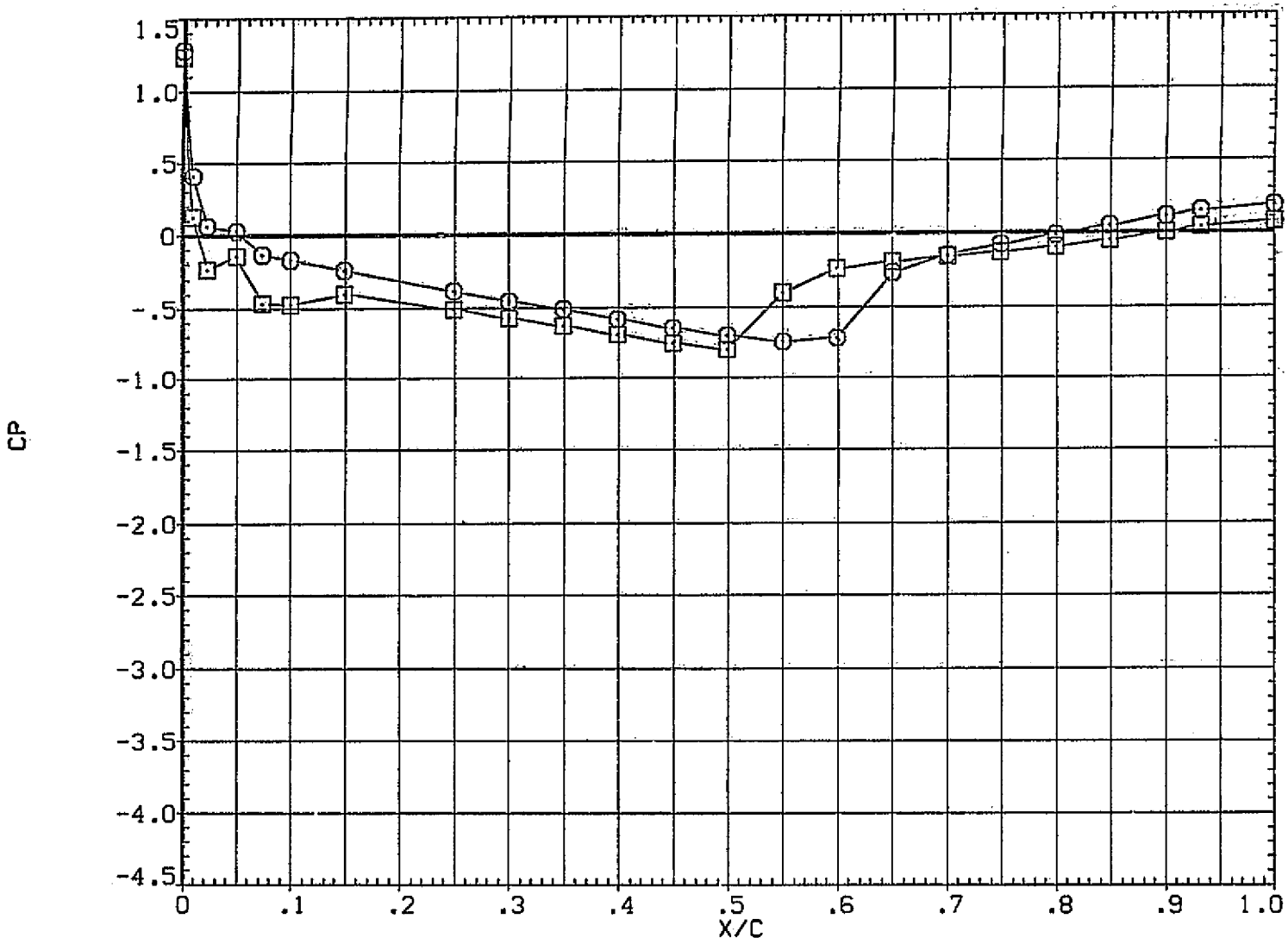

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIØNS IN ARGØN

ARGON AIRFOIL UPPER SURFACE (RLAA14)

SYMBOL	ALPHA	Y	MACH
○	-.968	.000	.874
□	.661		

PARAMETRIC VALUES

RN 2.000

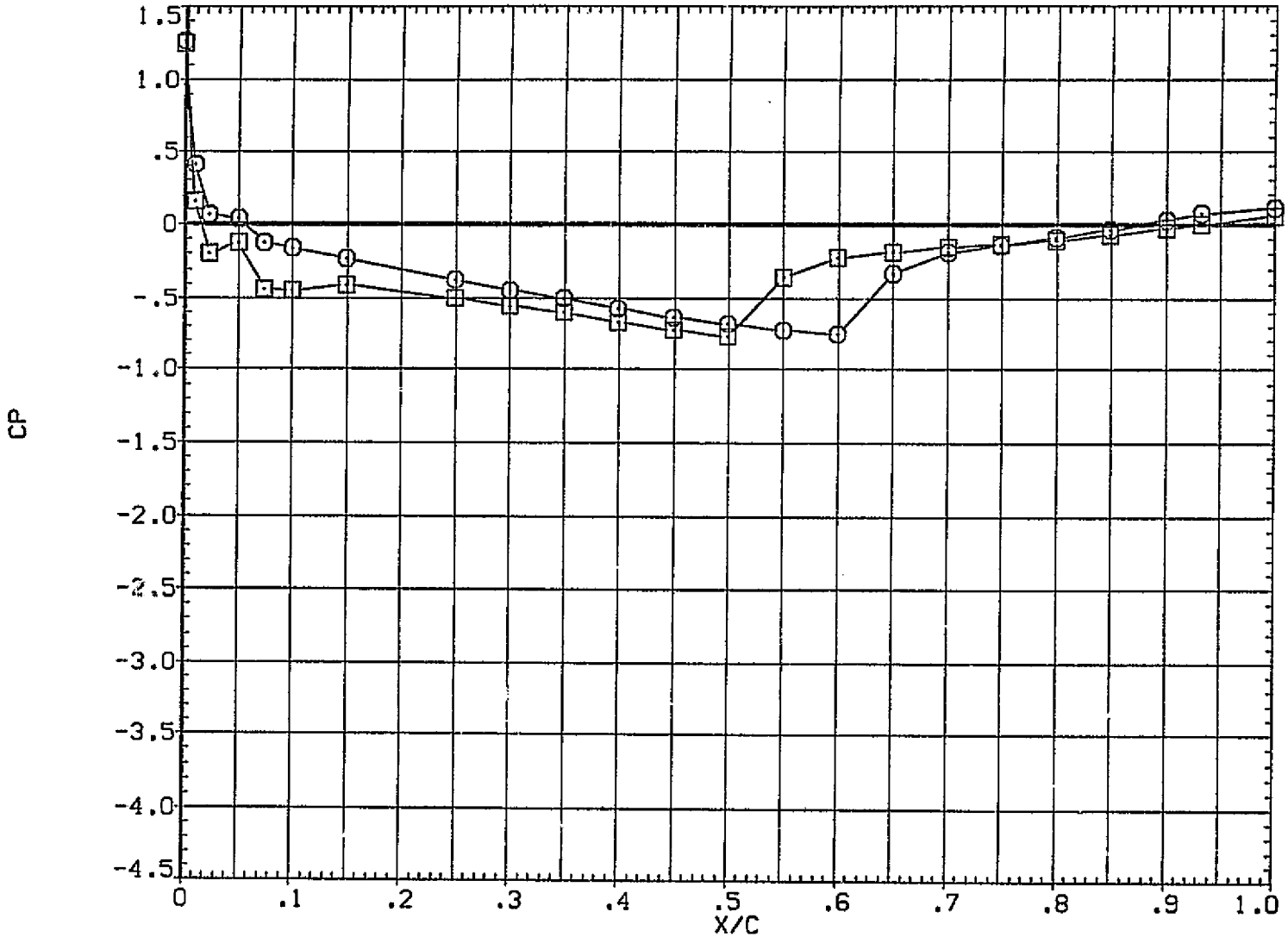

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

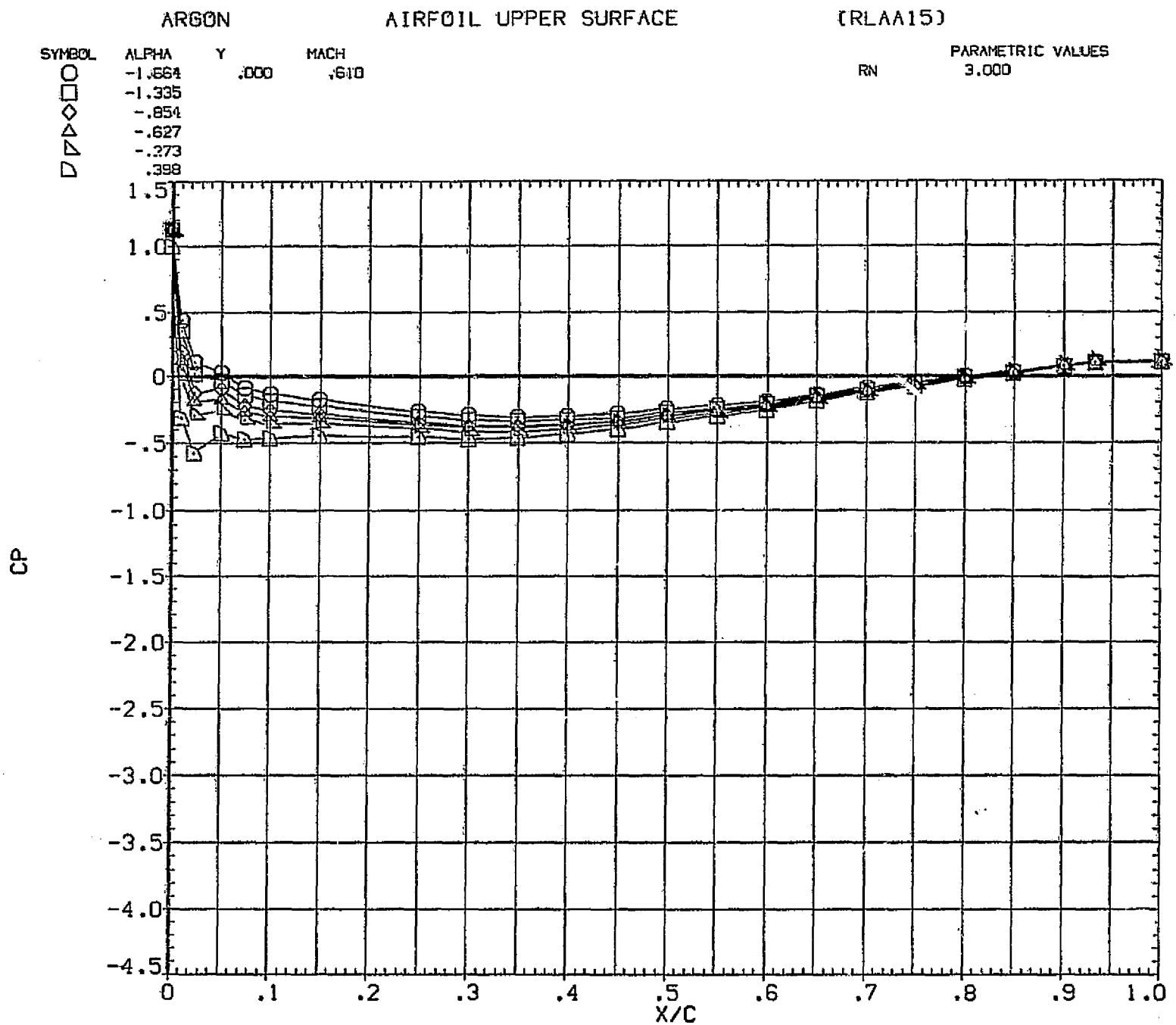

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

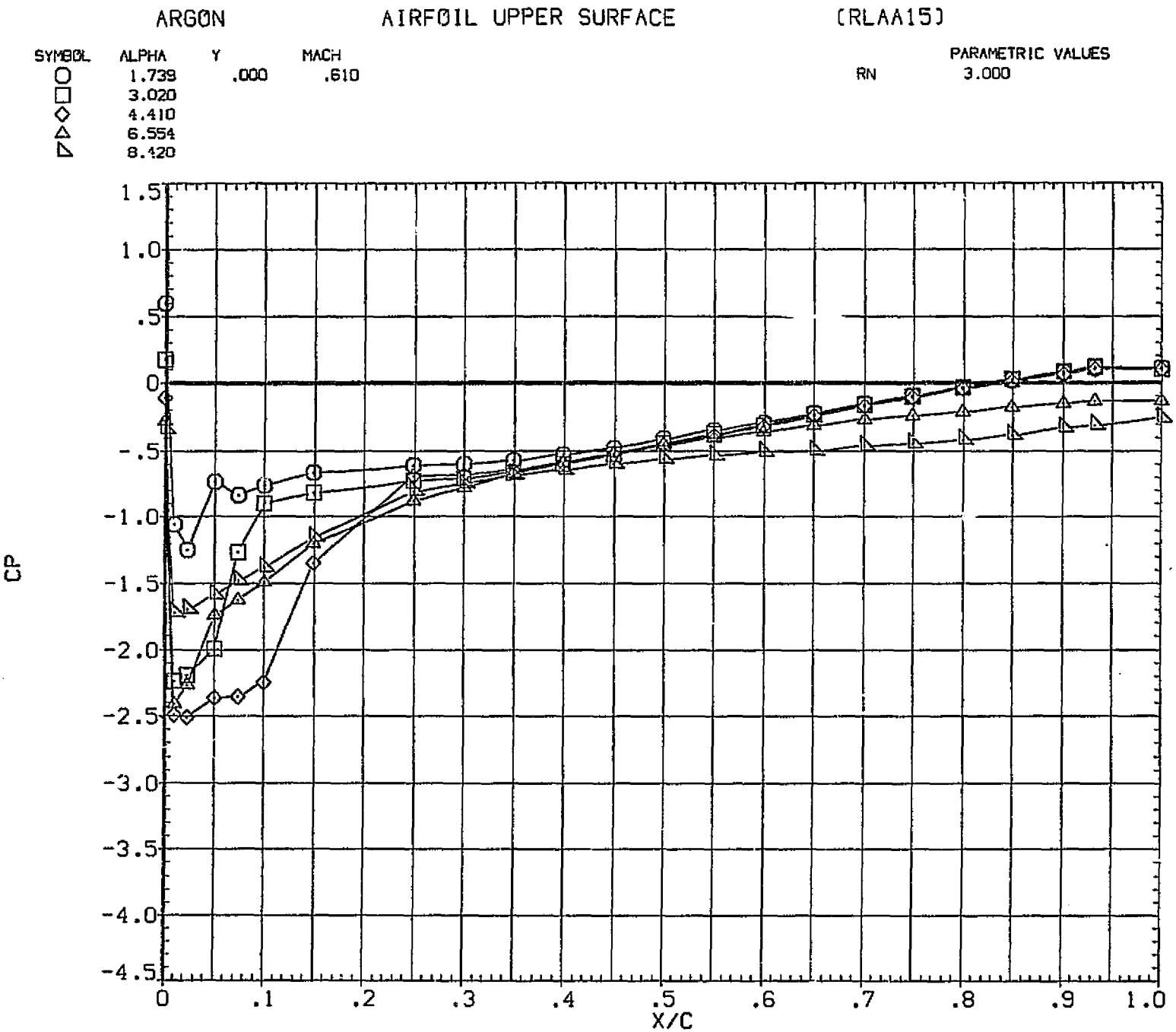

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

ARGØN AIRFØIL UPPER SURFACE (RLAA15)

SYMBOL	ALPHA	Y	MACH
O	.129	.000	.785

PARAMETRIC VALUES
RN 3.000

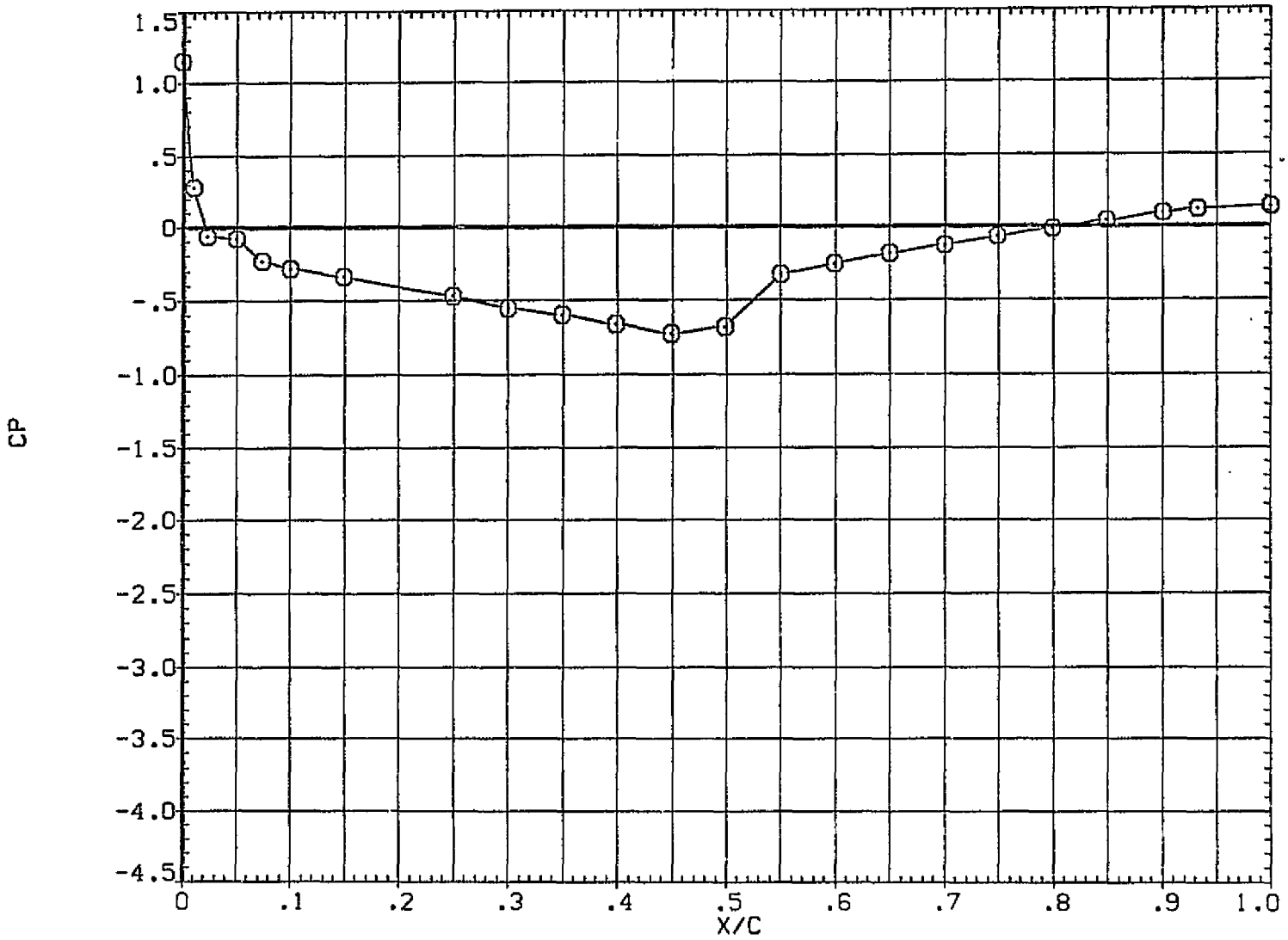

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGØN

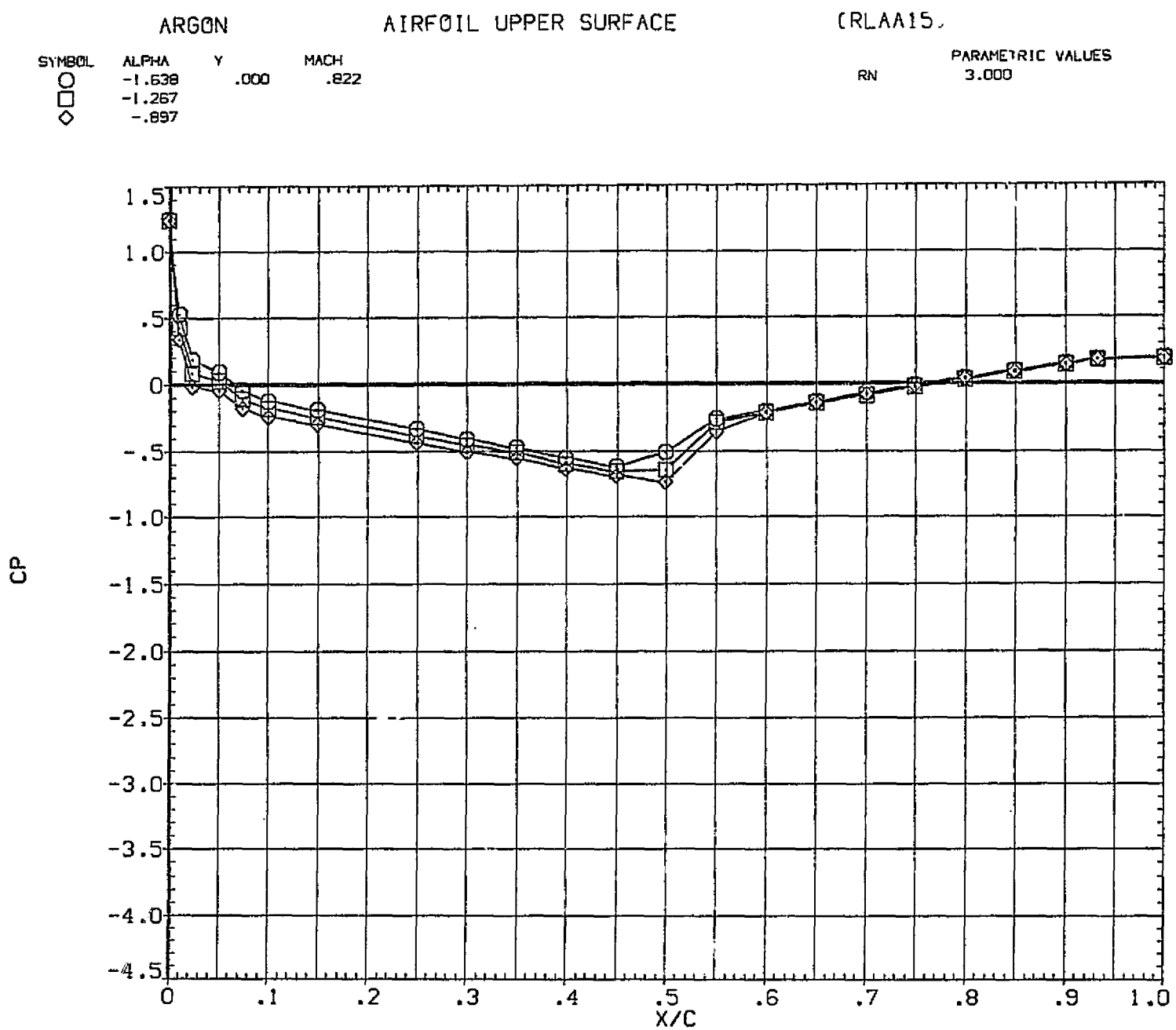

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

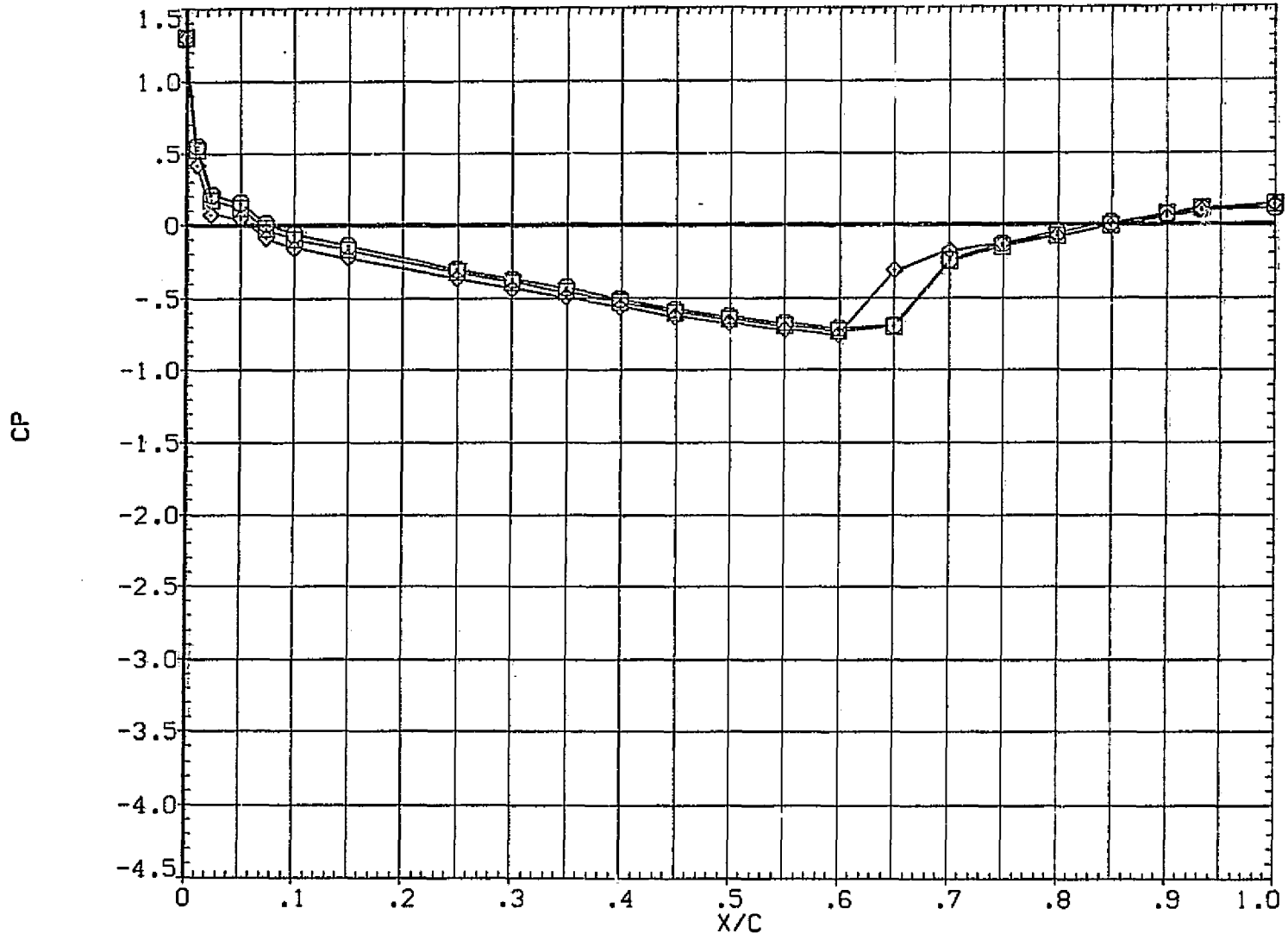

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

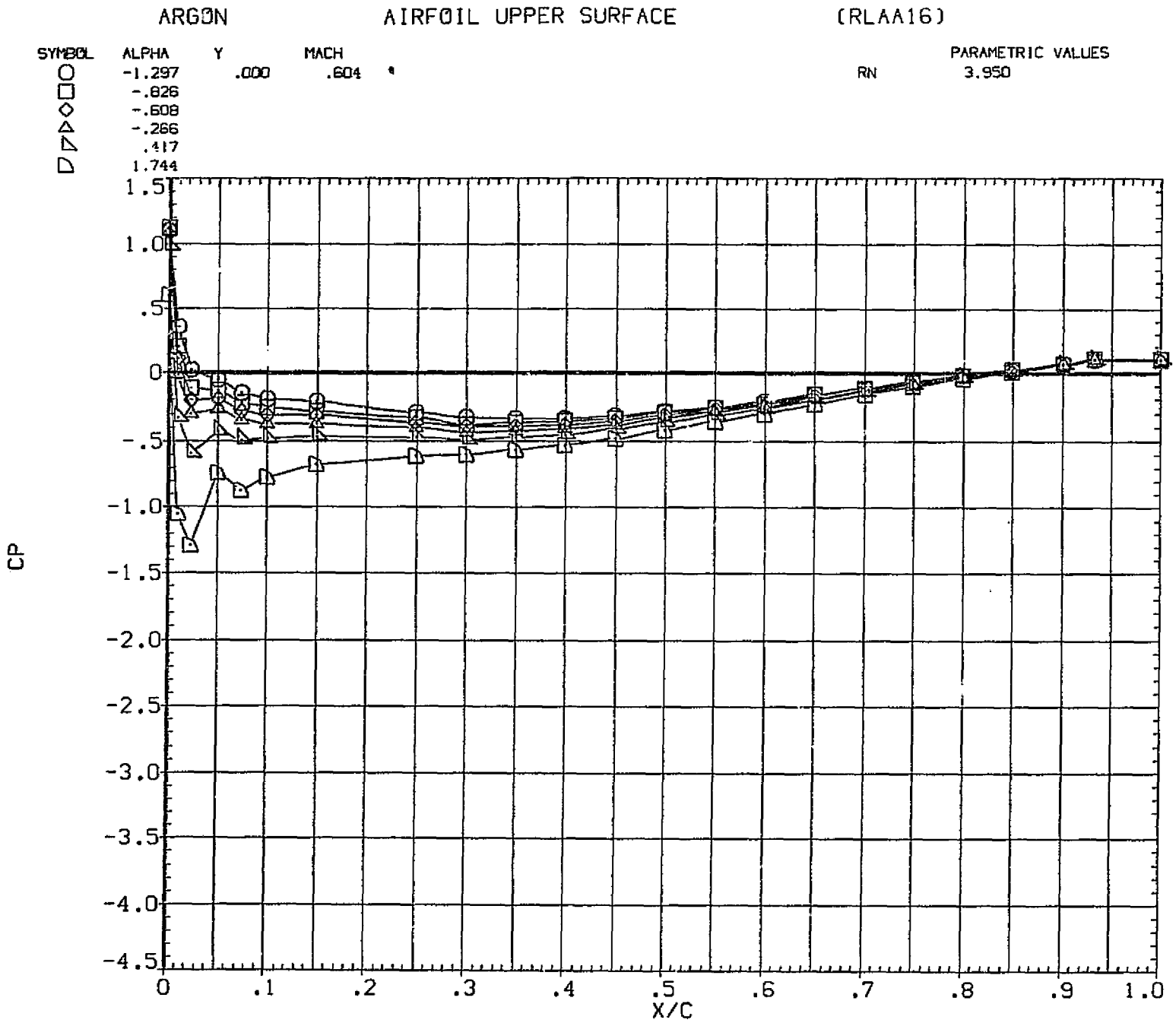

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

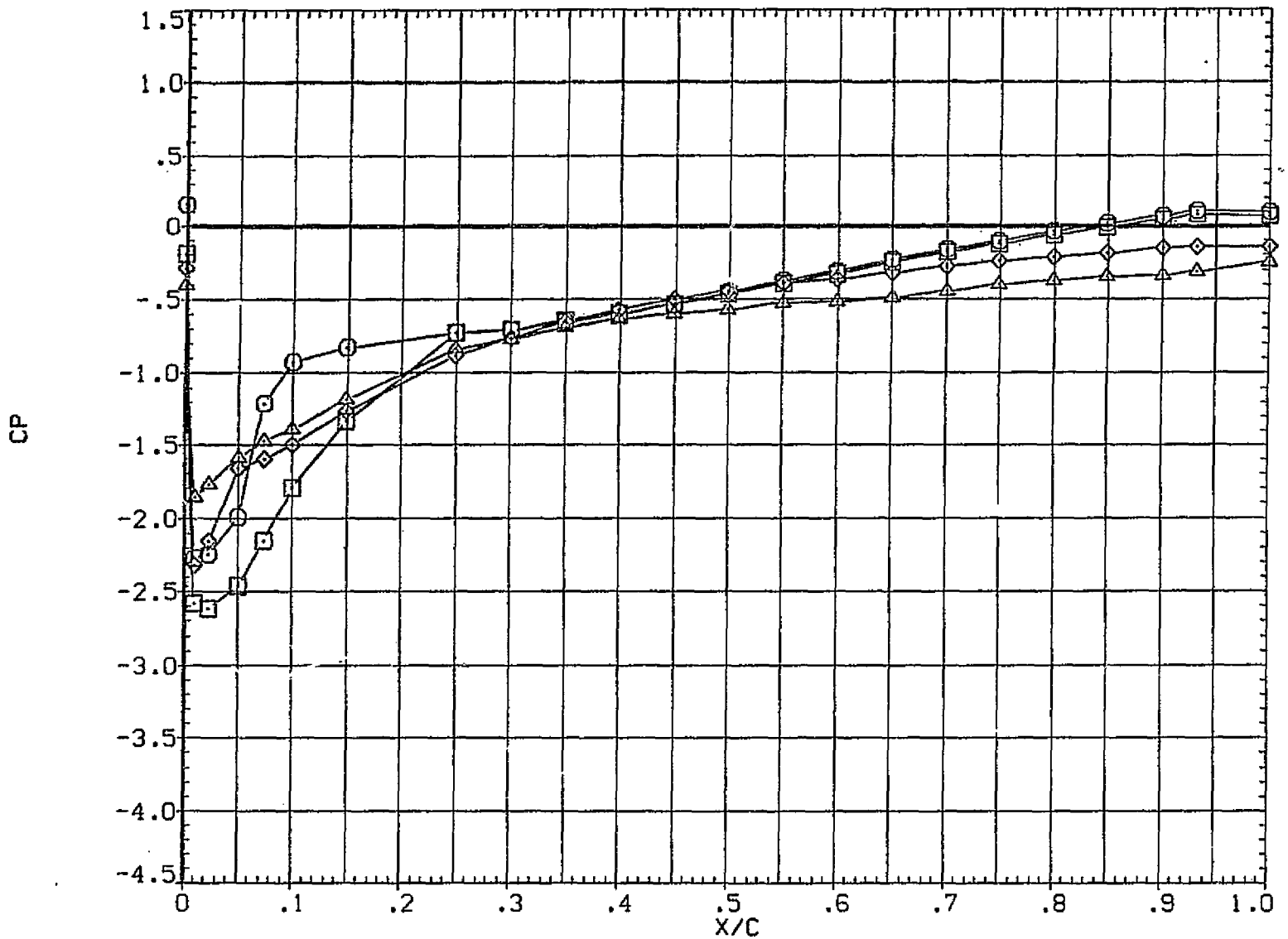

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

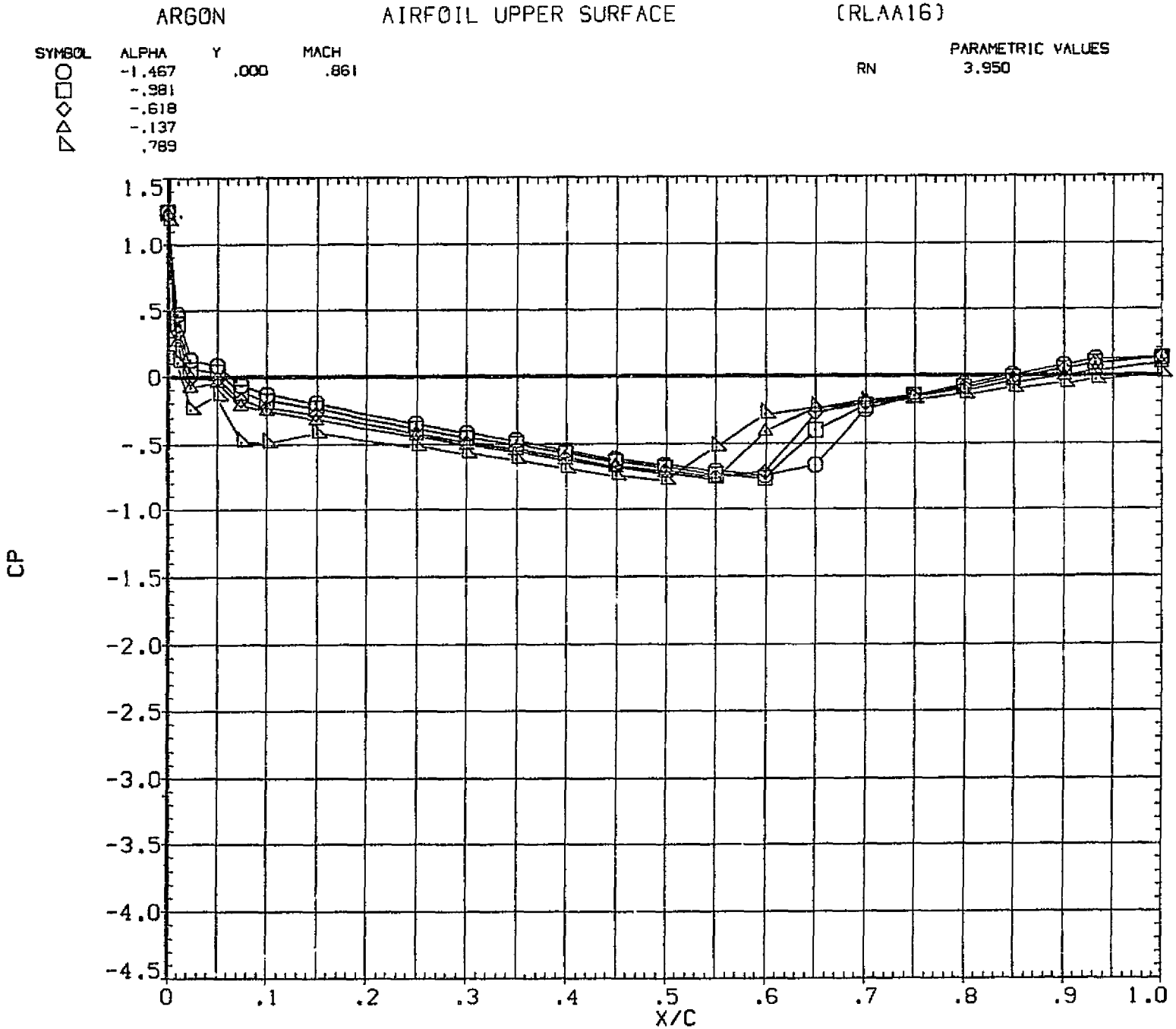

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

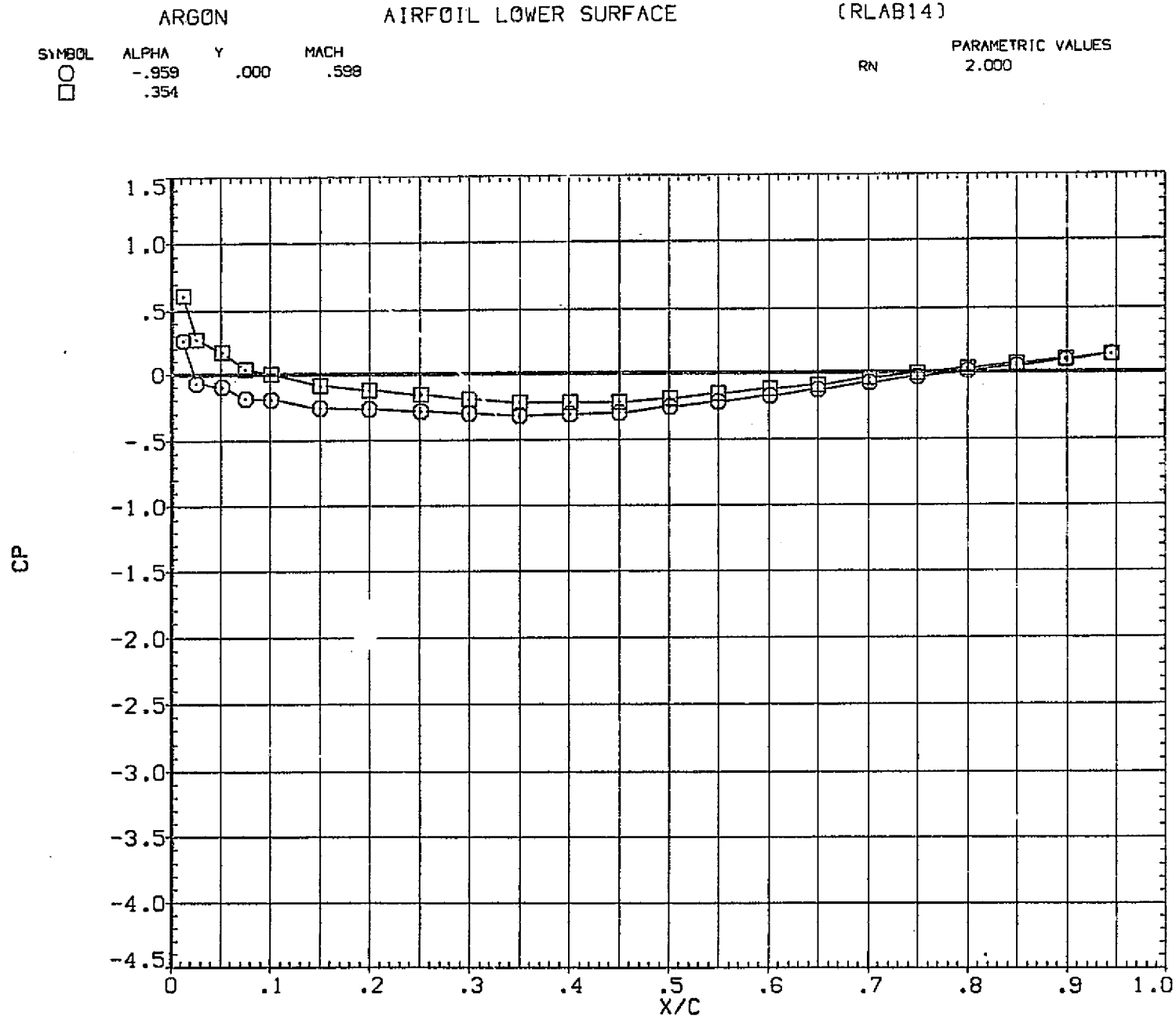

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

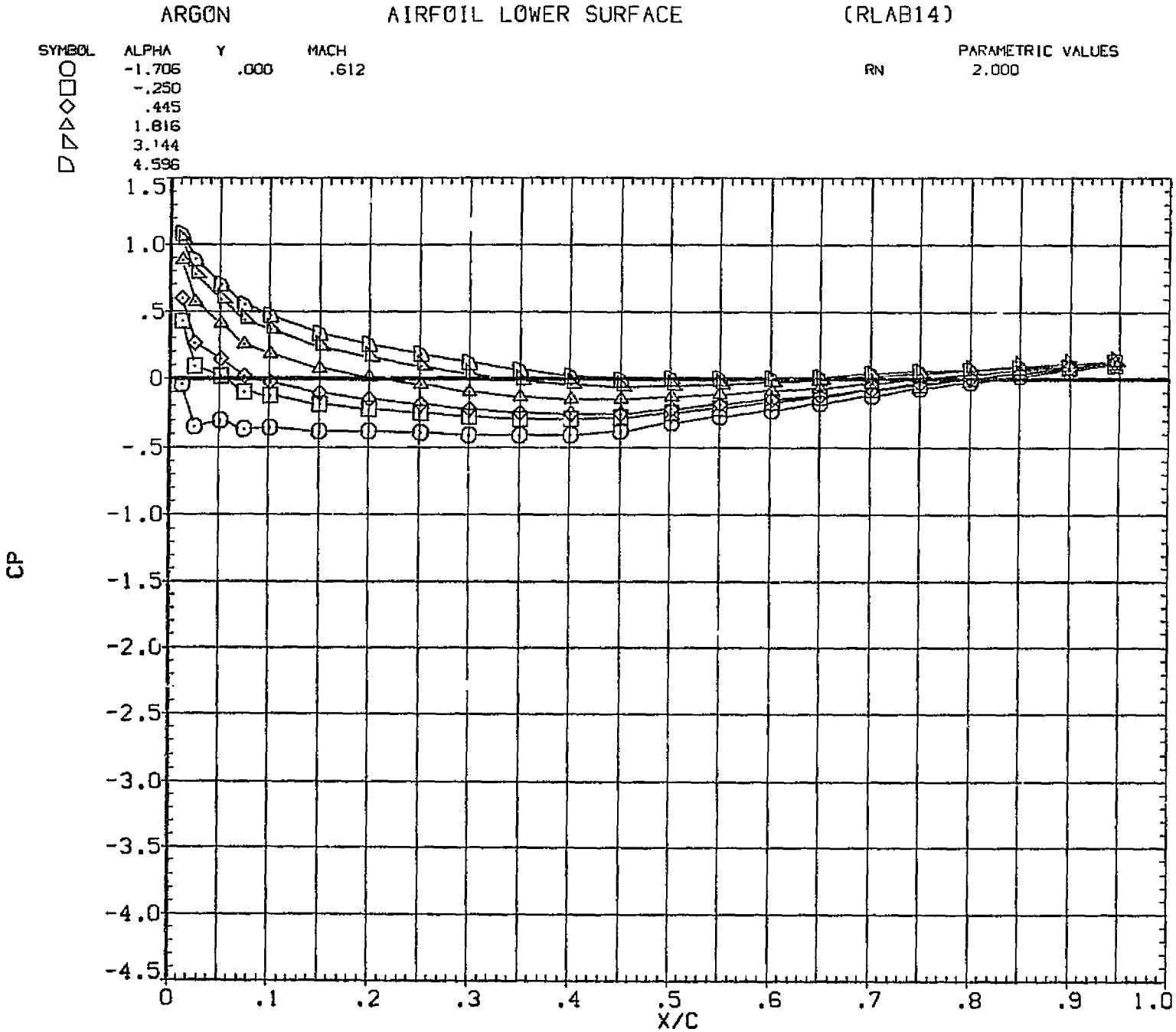

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

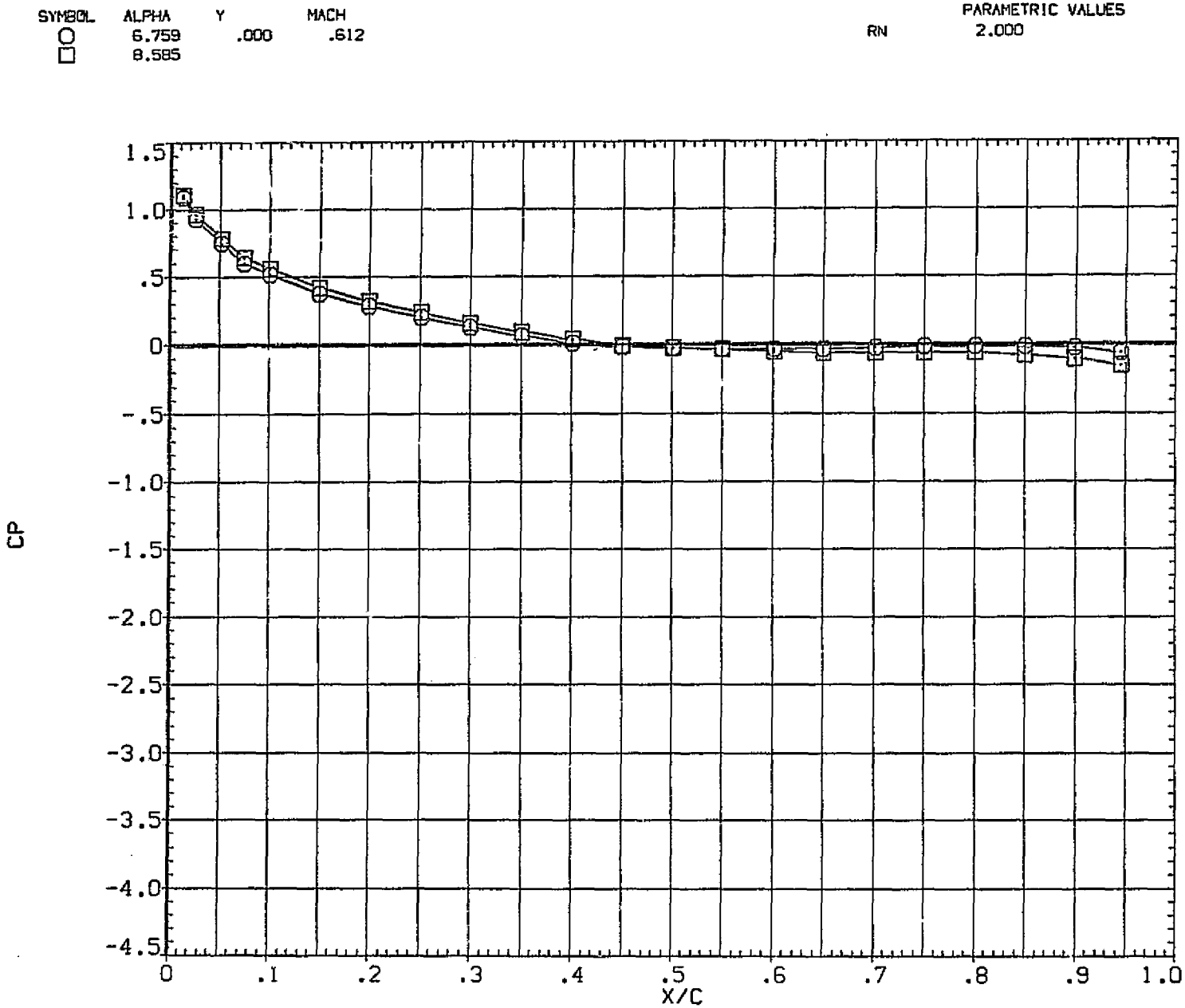

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

ARGON AIRFOIL LOWER SURFACE (RLAB14)

SYMBOL	ALPHA	Y	MACH
○	-.942	.000	.816
□	.136		

PARAMETRIC VALUES

RN 2.000

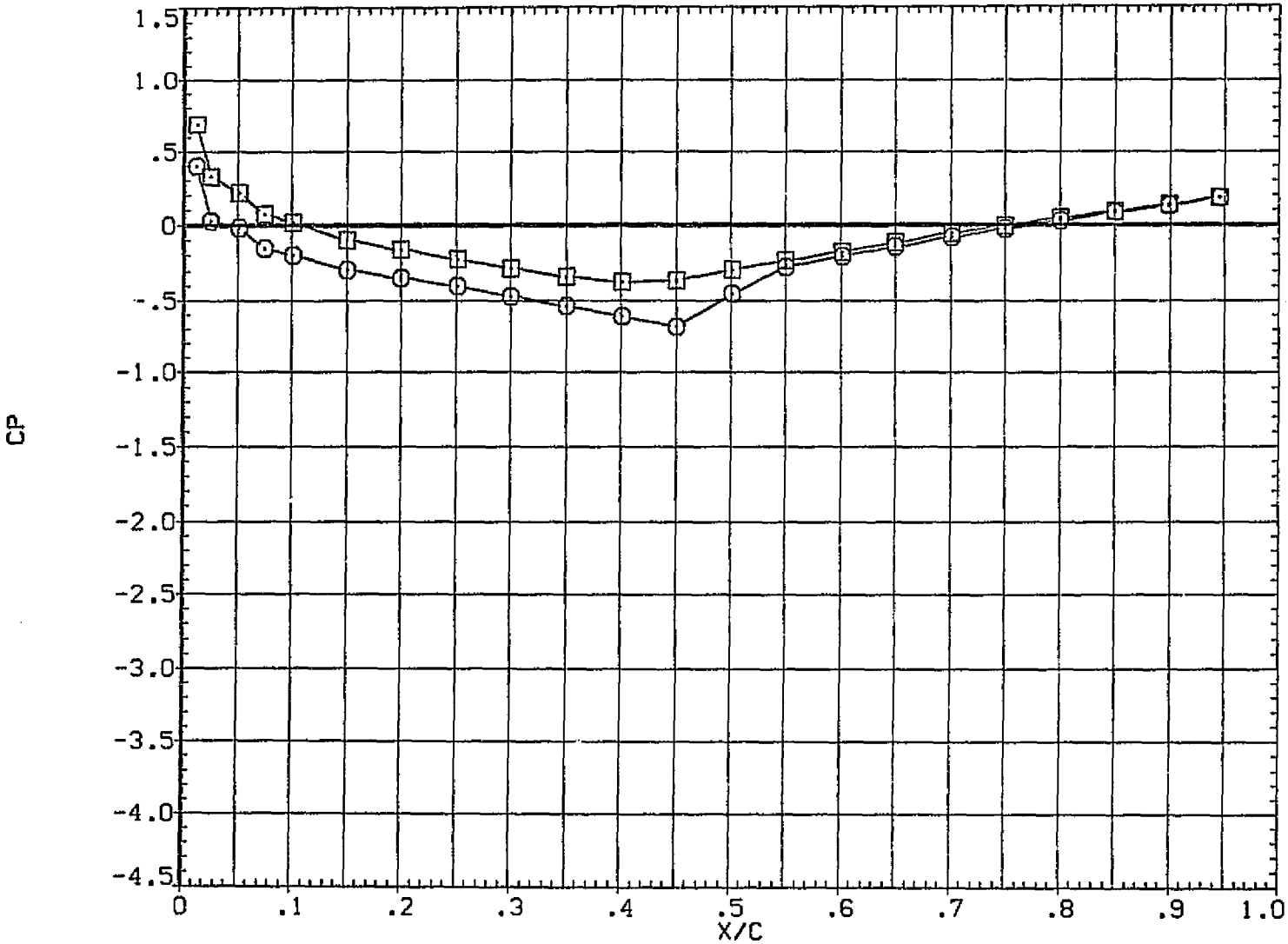

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

SYMBOL	ALPHA	Y	MACH
○	-.946	.000	.823
□	.152		

PARAMETRIC VALUES
RN 2.000

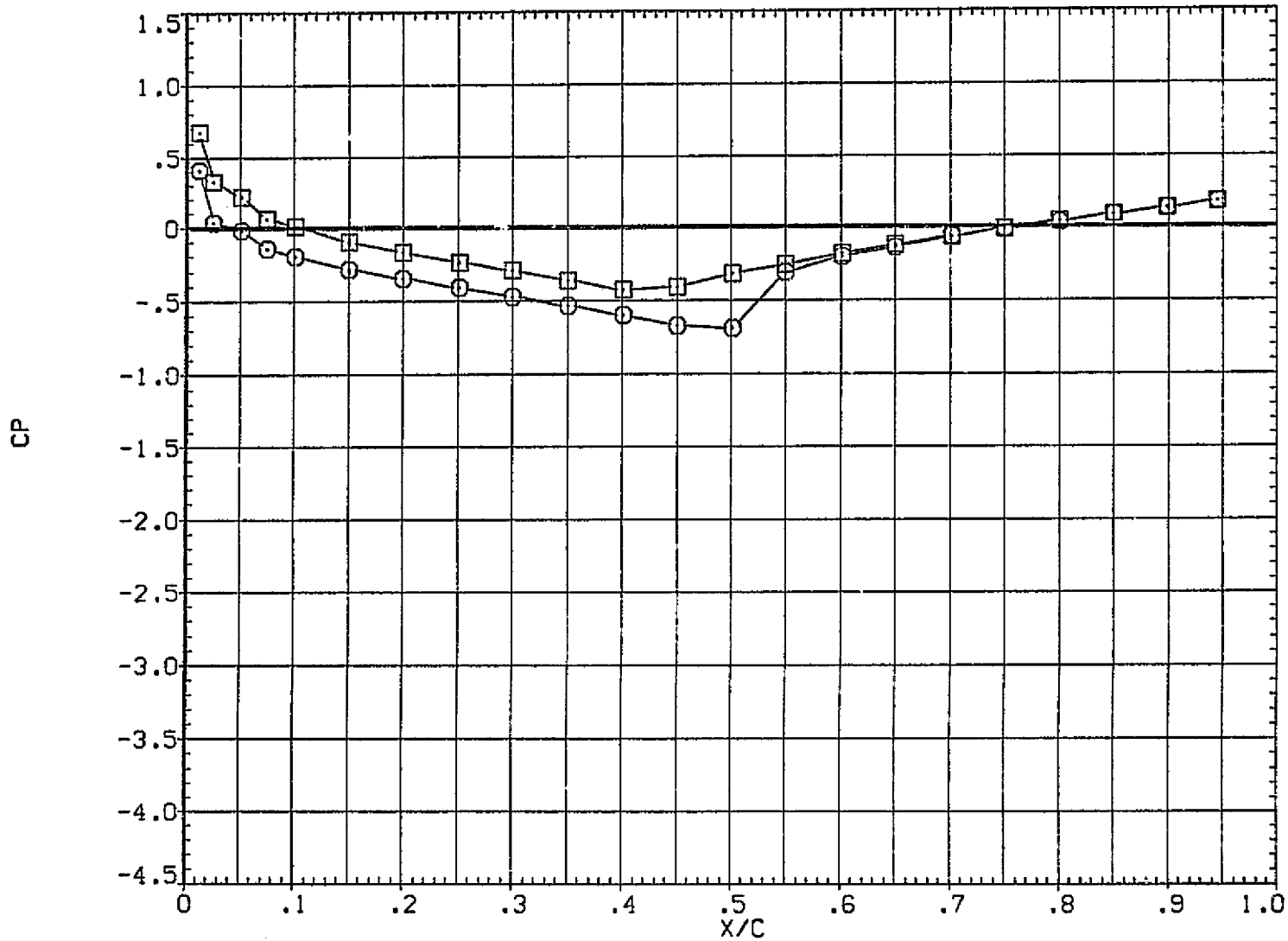

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

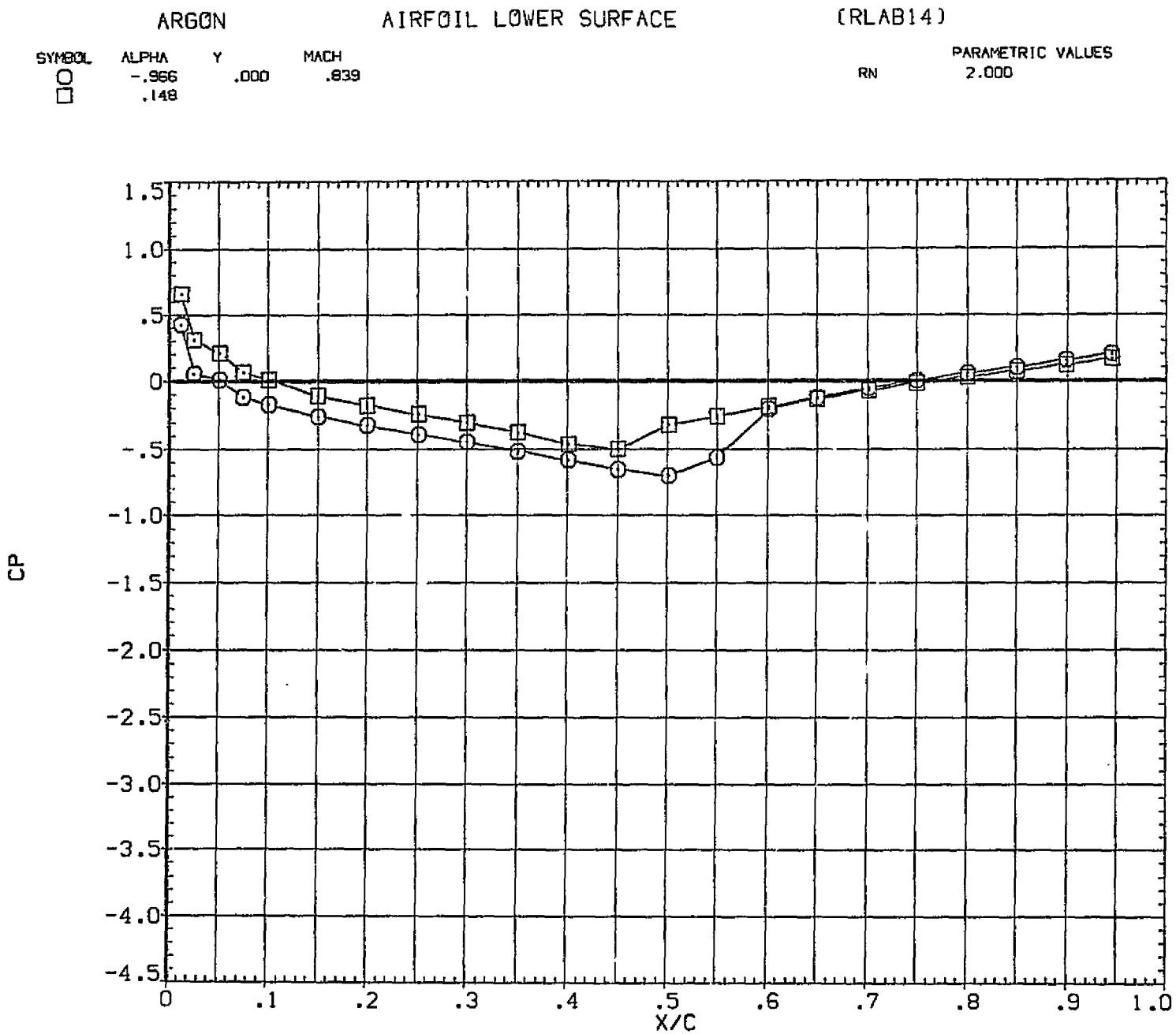

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

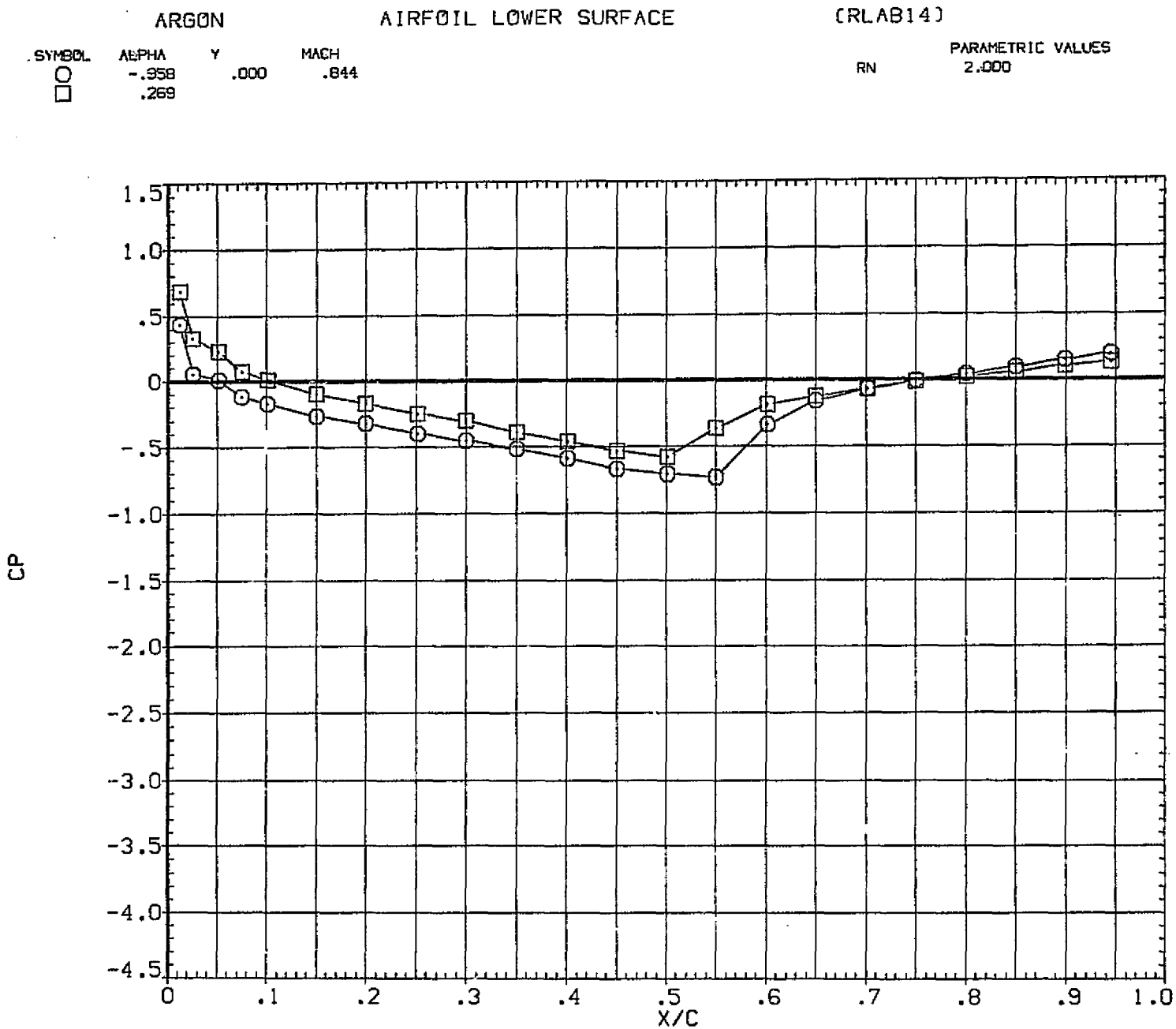

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

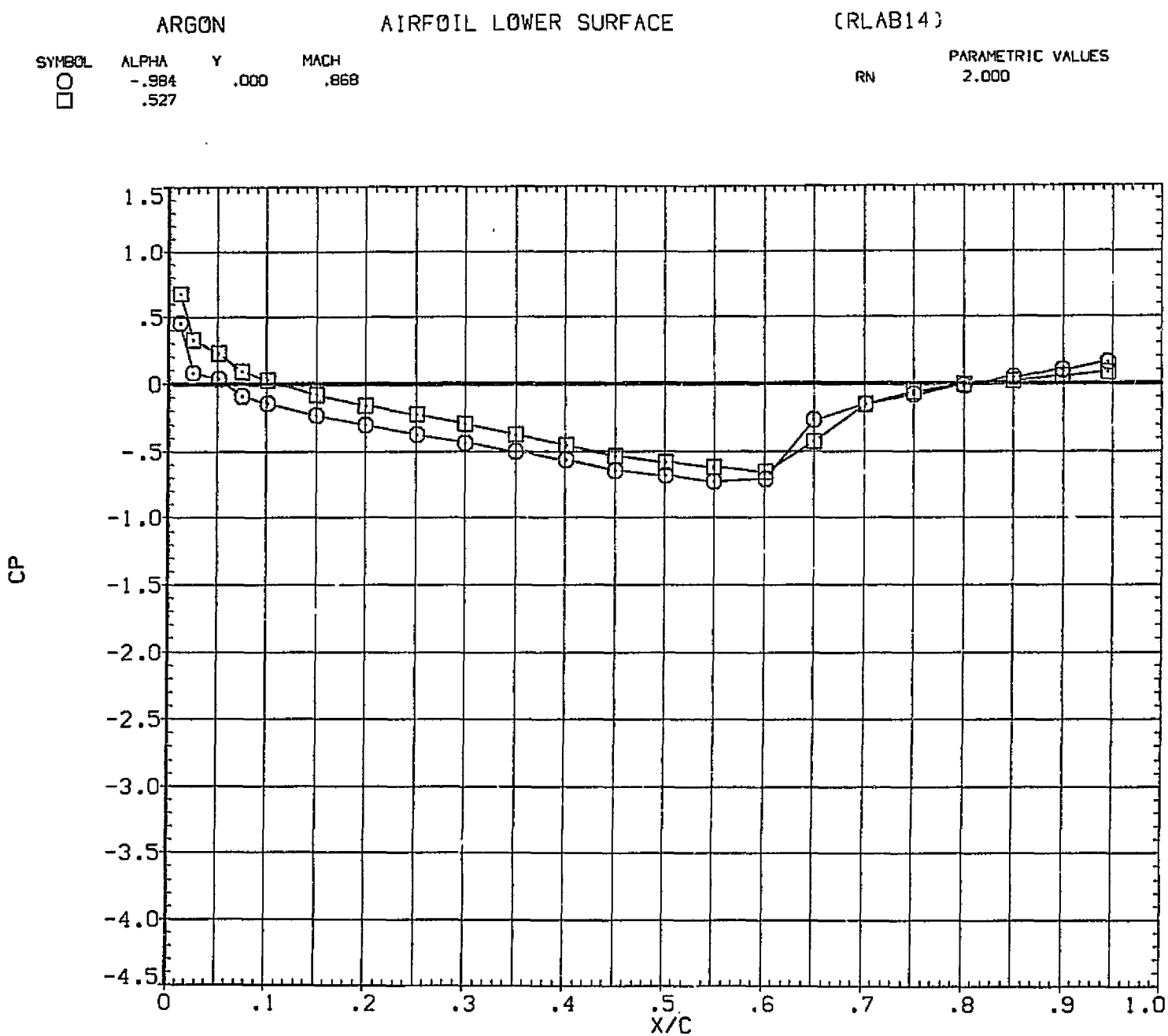

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

SYMBOL	ALPHA	Y	MACH
○	-.968	.000	.874
□	.661		

PARAMETRIC VALUES
RN 2.000

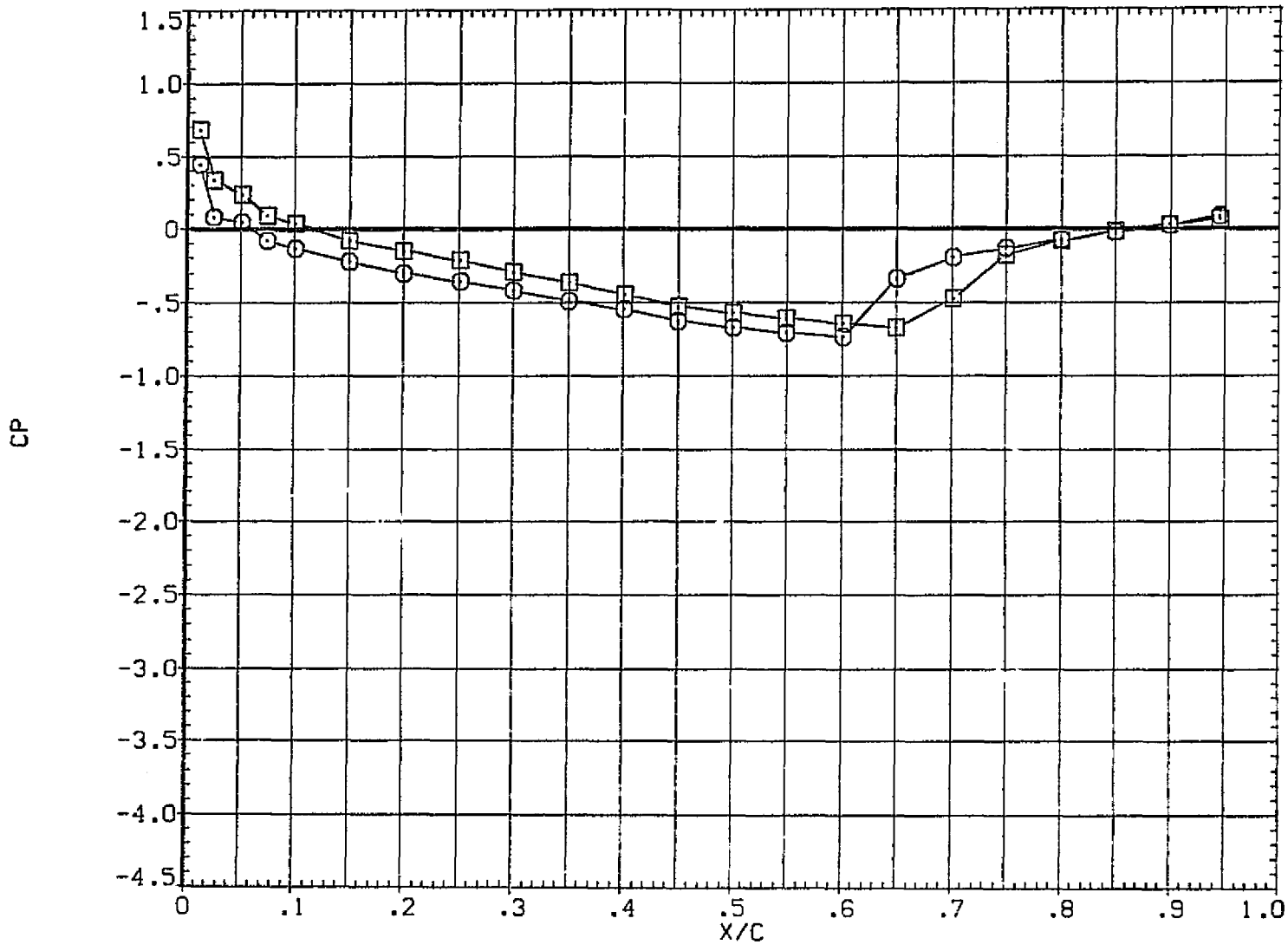

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

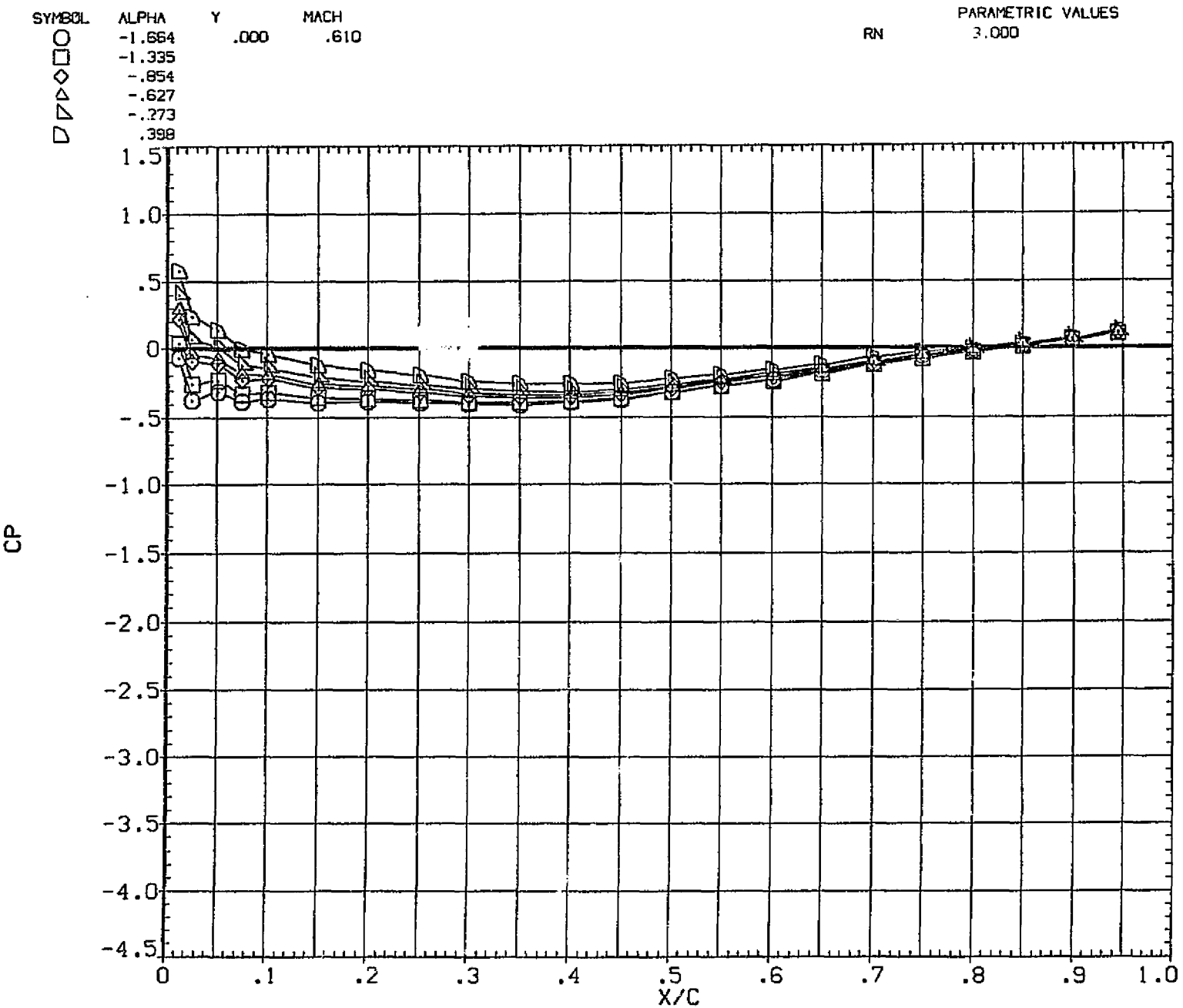

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

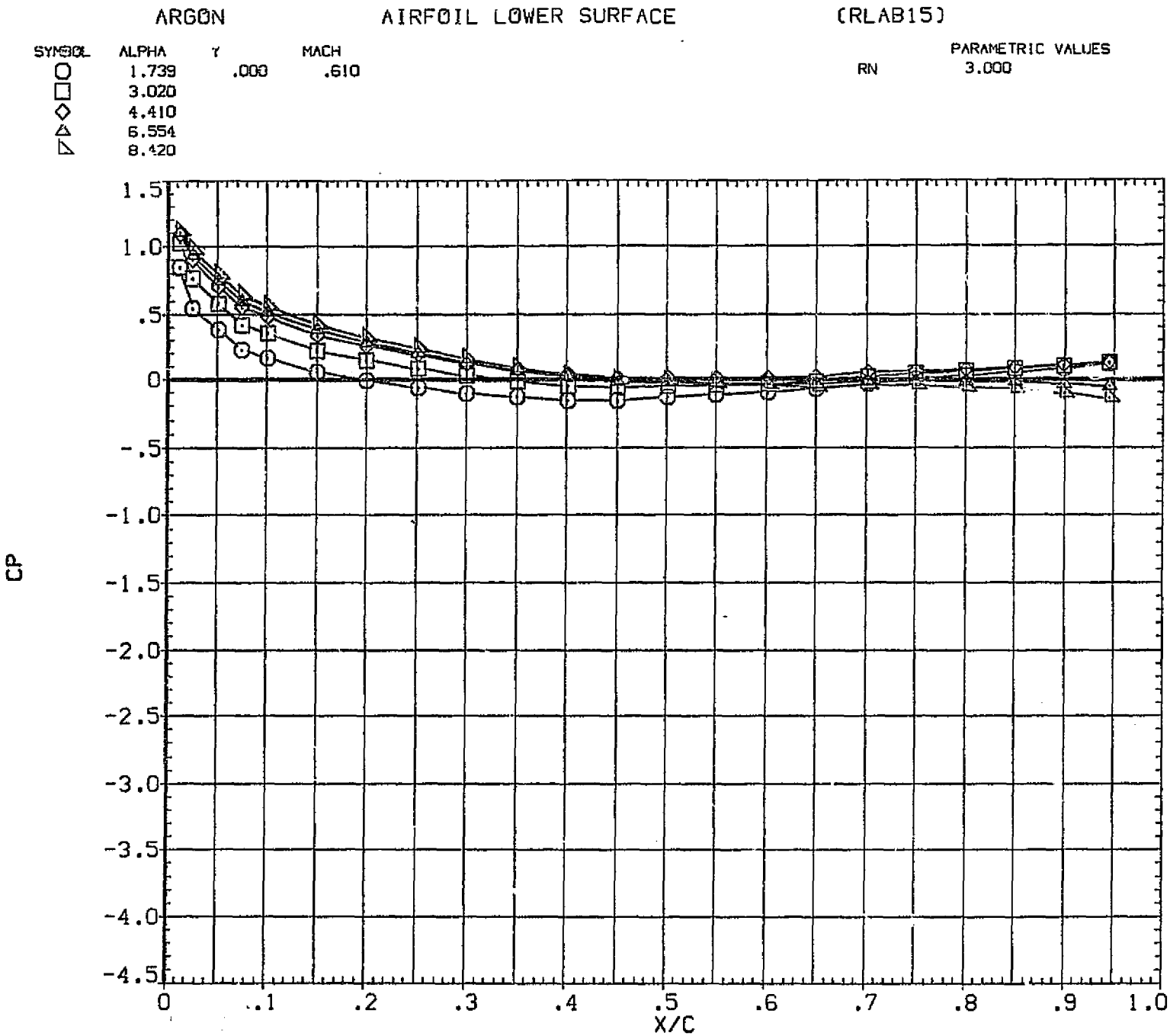

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

ARGON AIRFOIL LOWER SURFACE (RLAB15)

SYMBOL	ALPHA	Y	MACH
O	.129	.000	.785

PARAMETRIC VALUES

RN 3.000

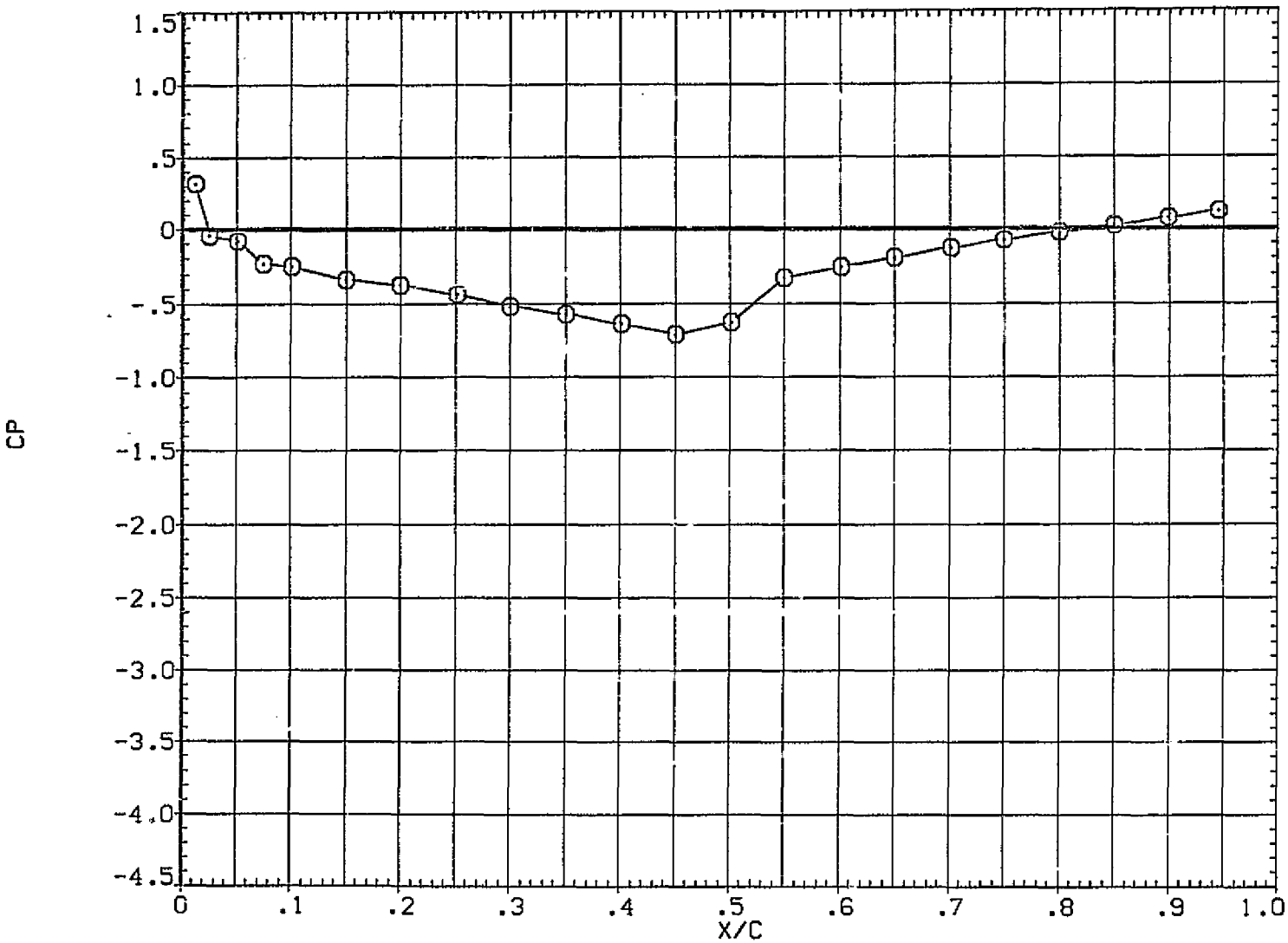

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

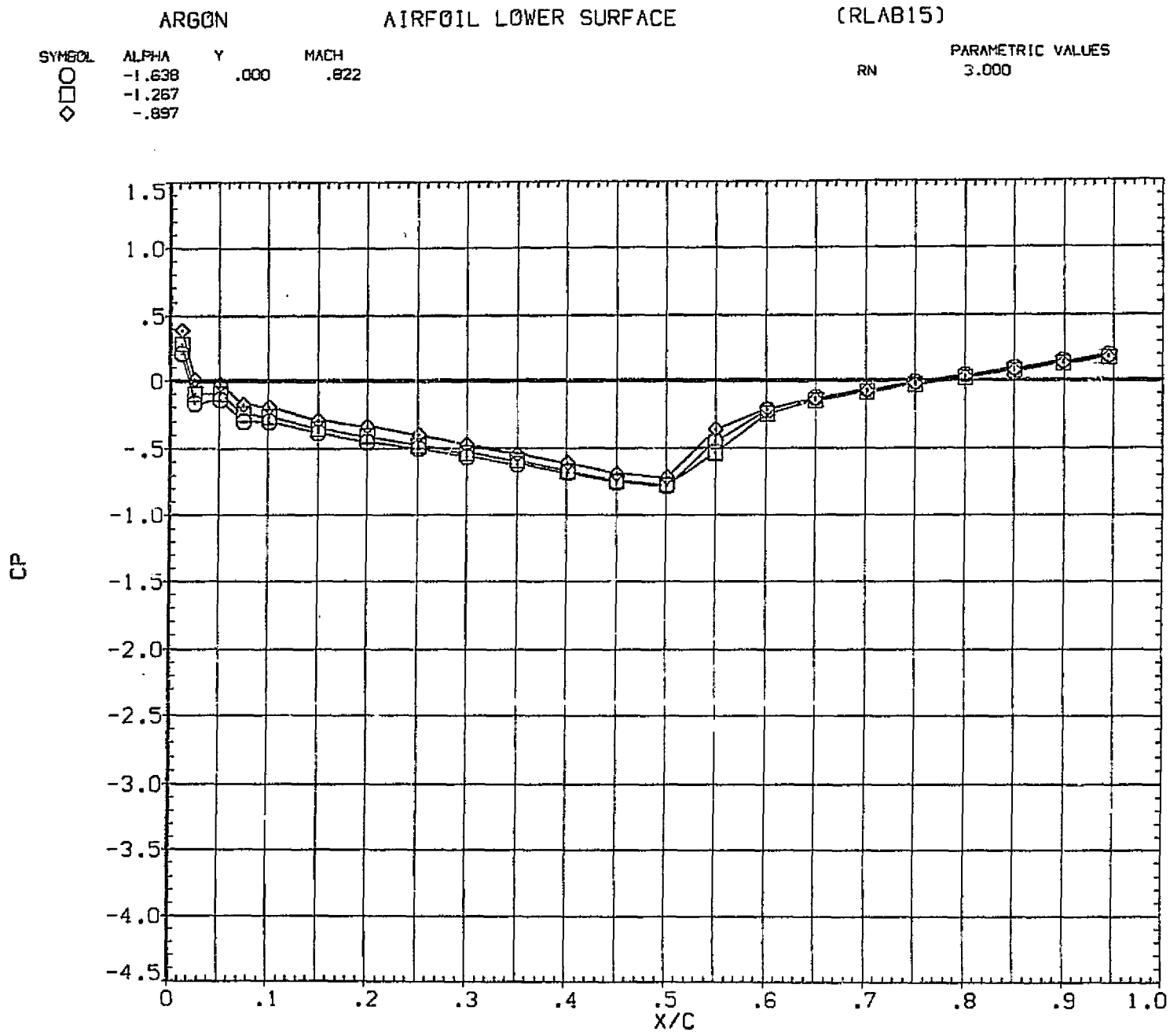

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

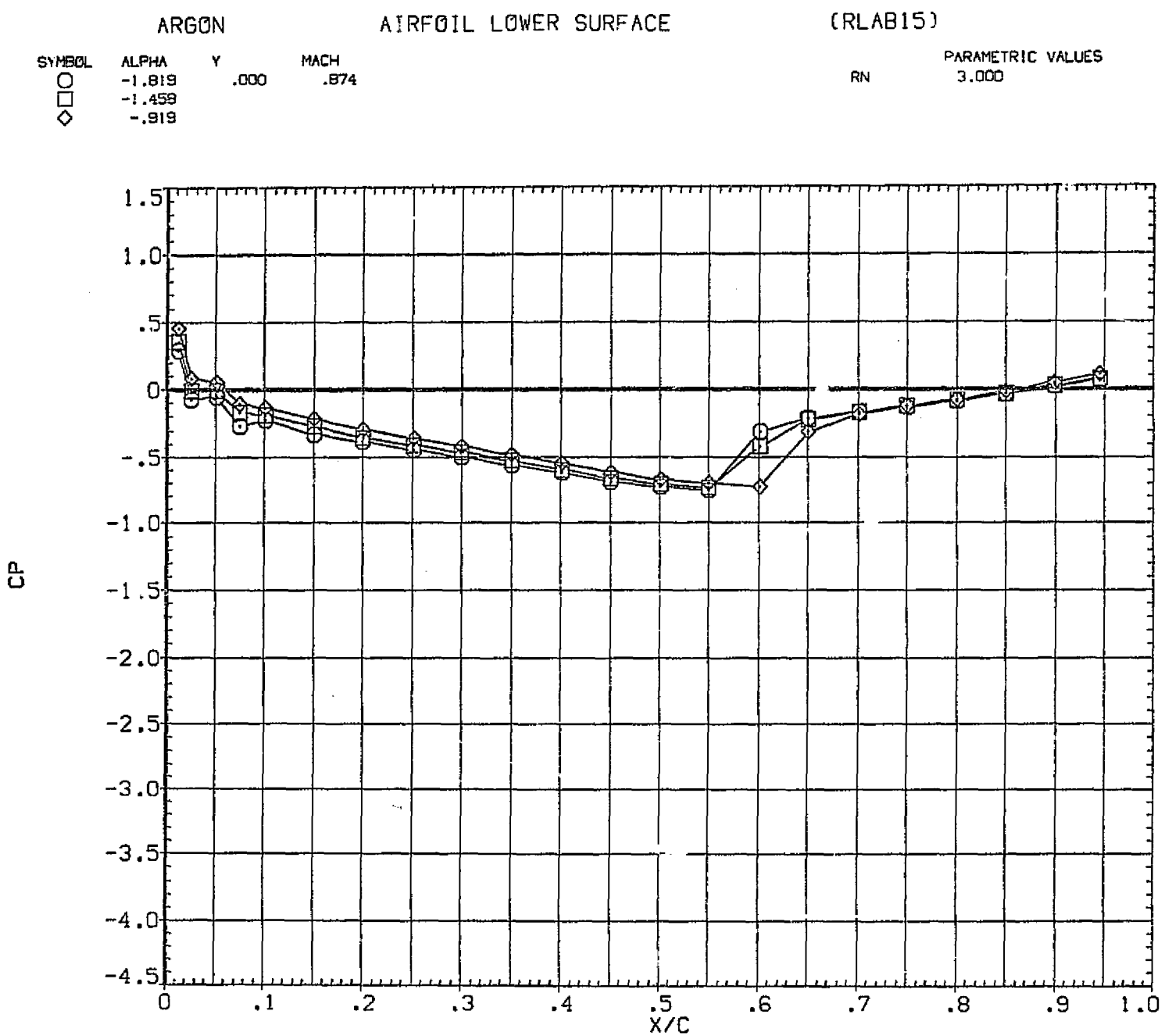

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

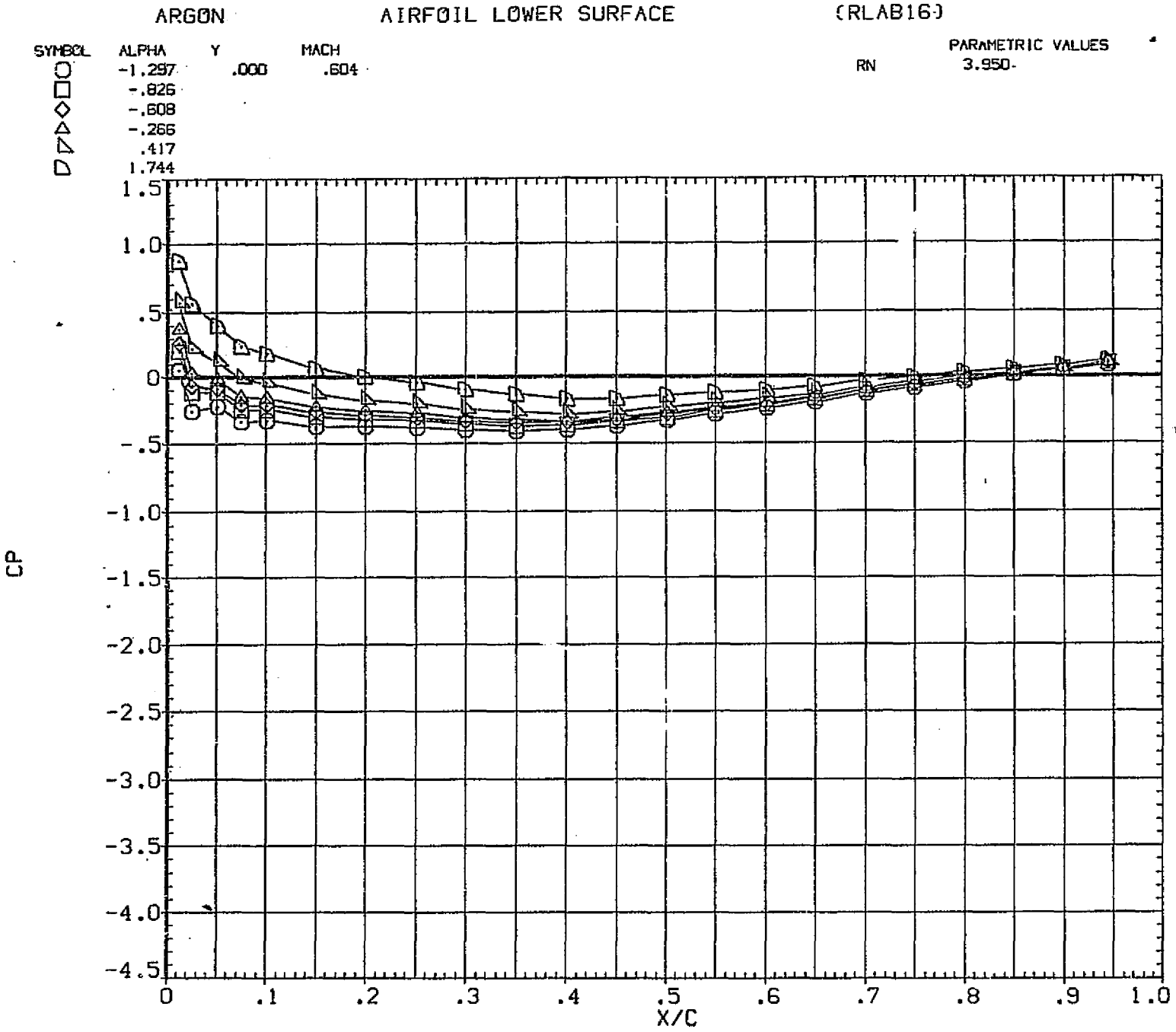

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

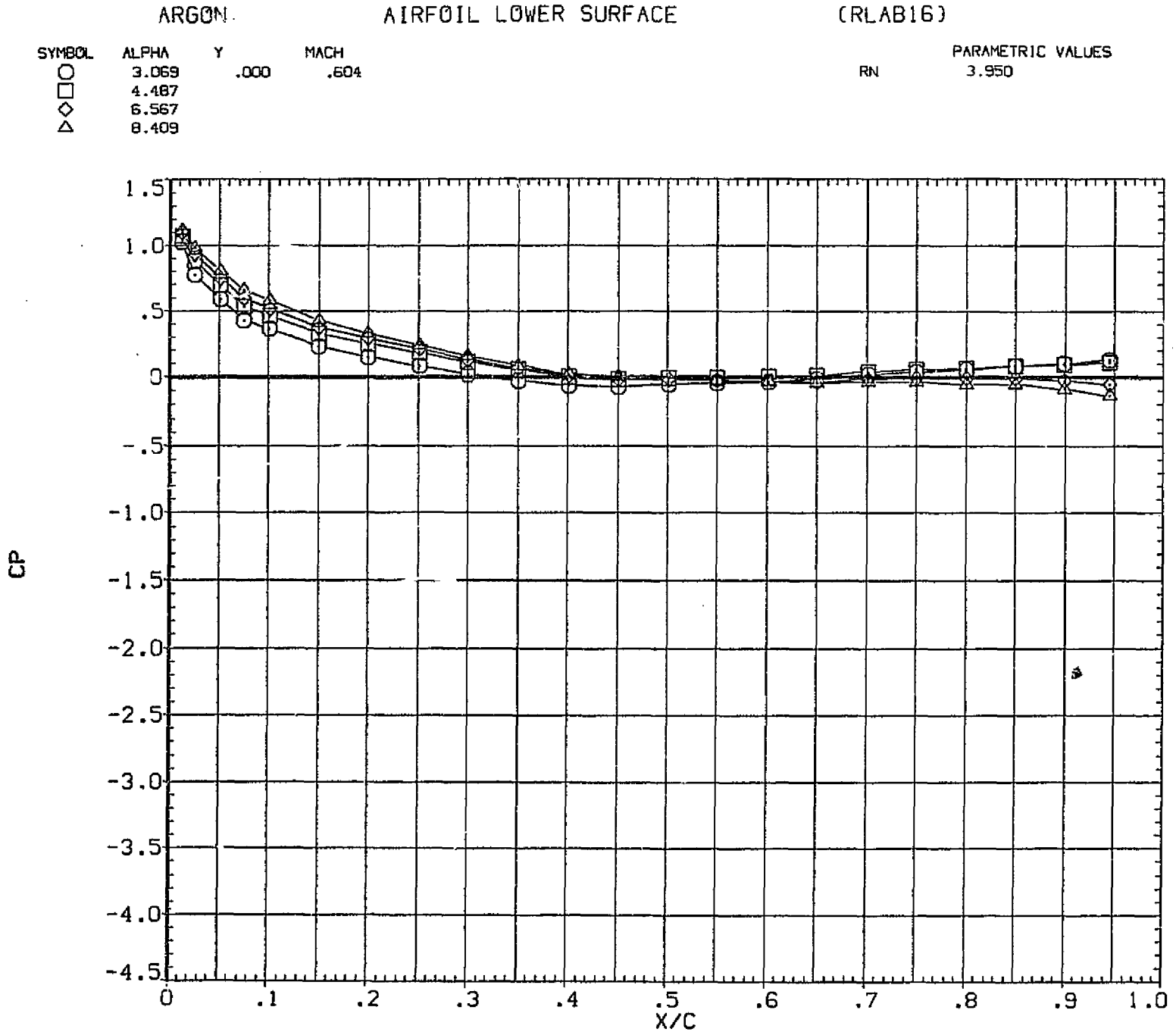

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

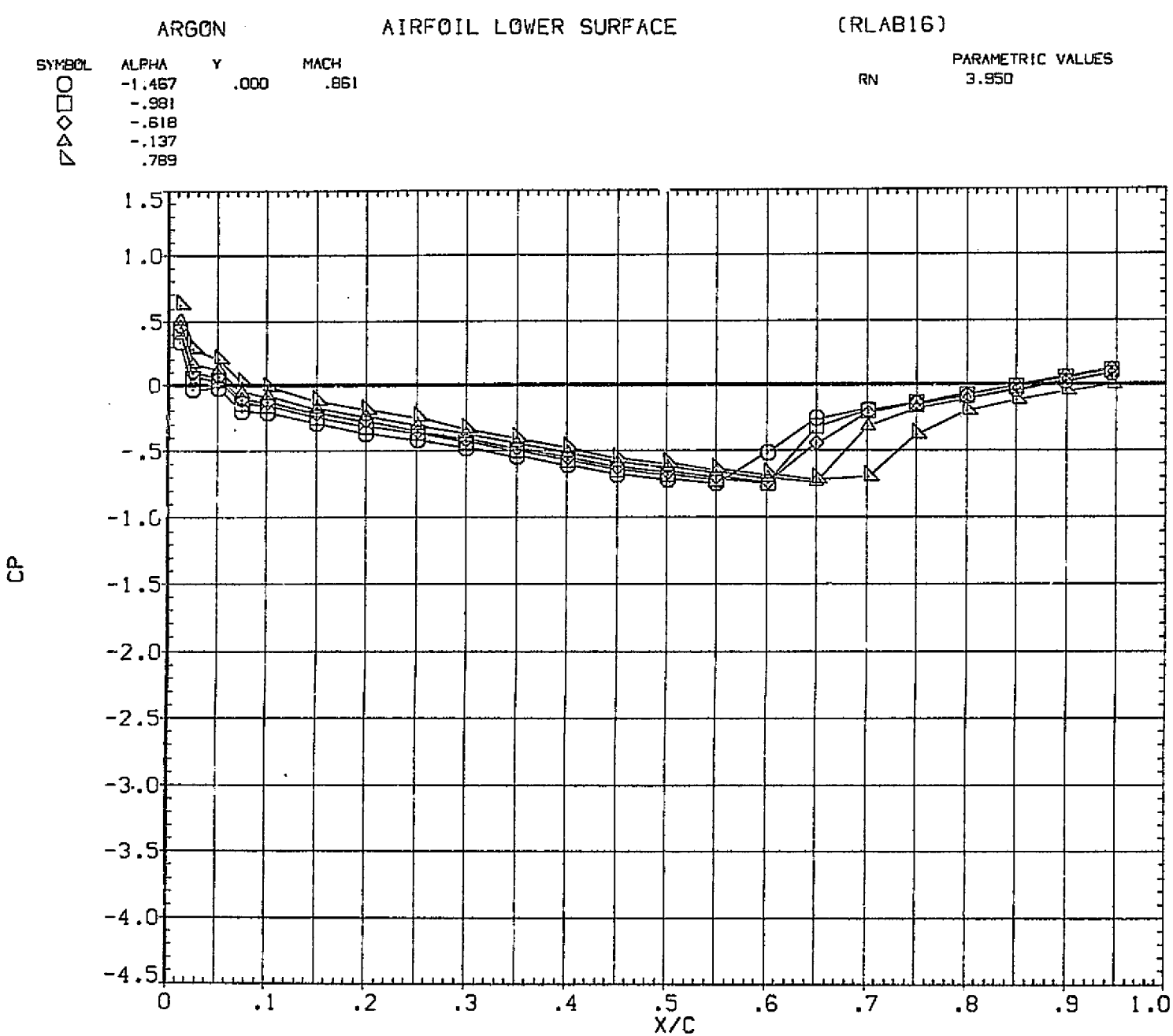

FIG. 4 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON

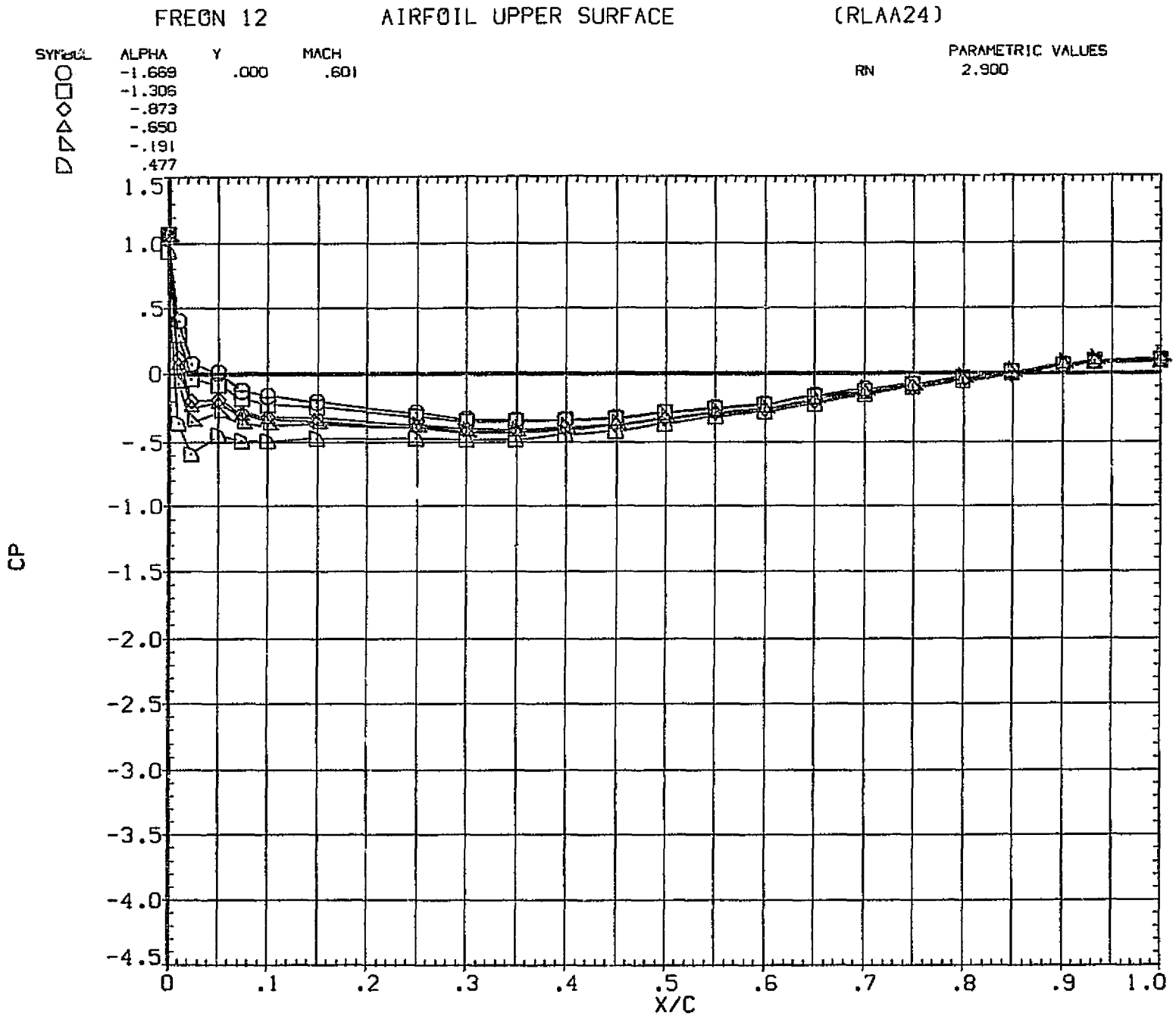

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

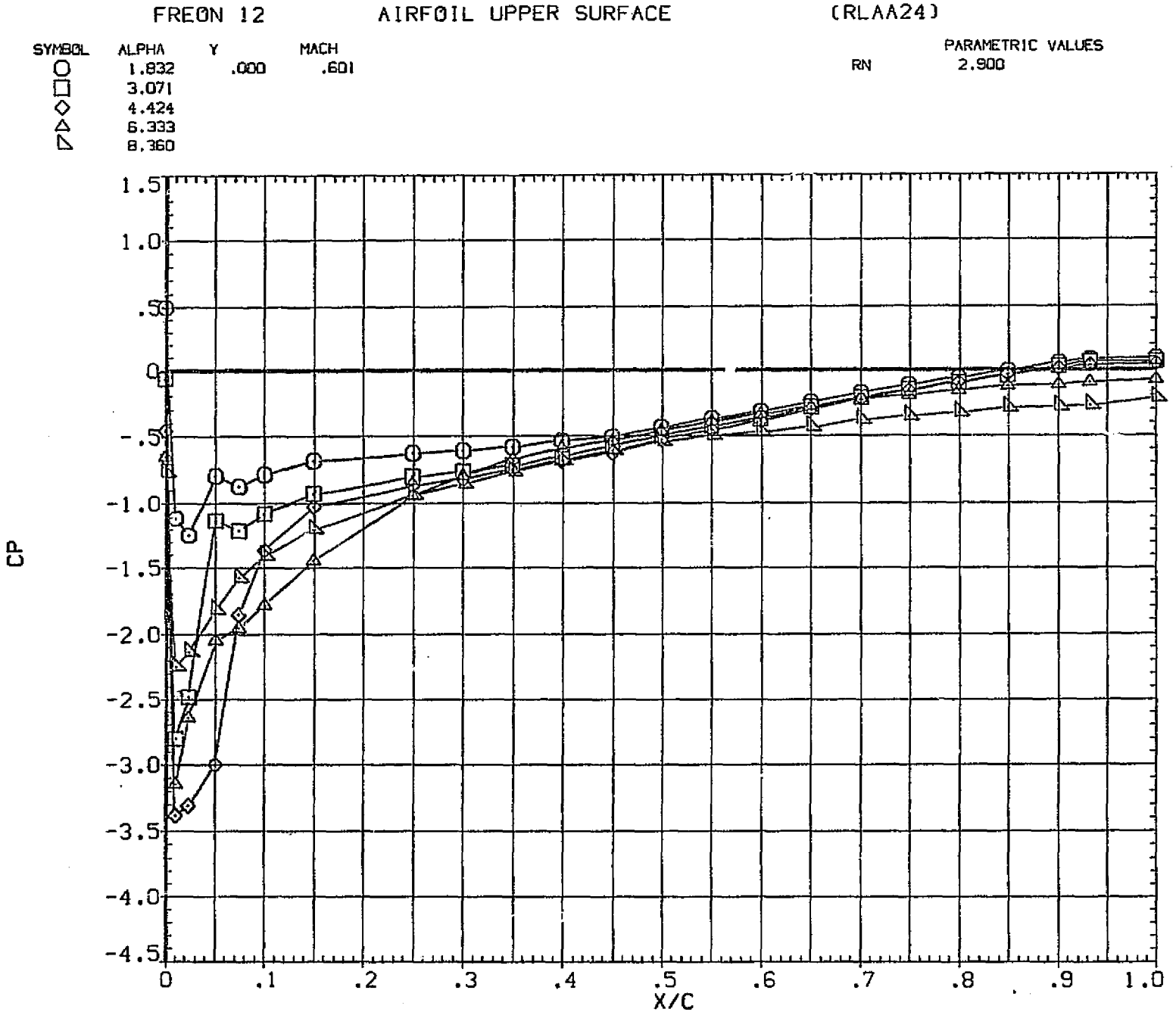

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

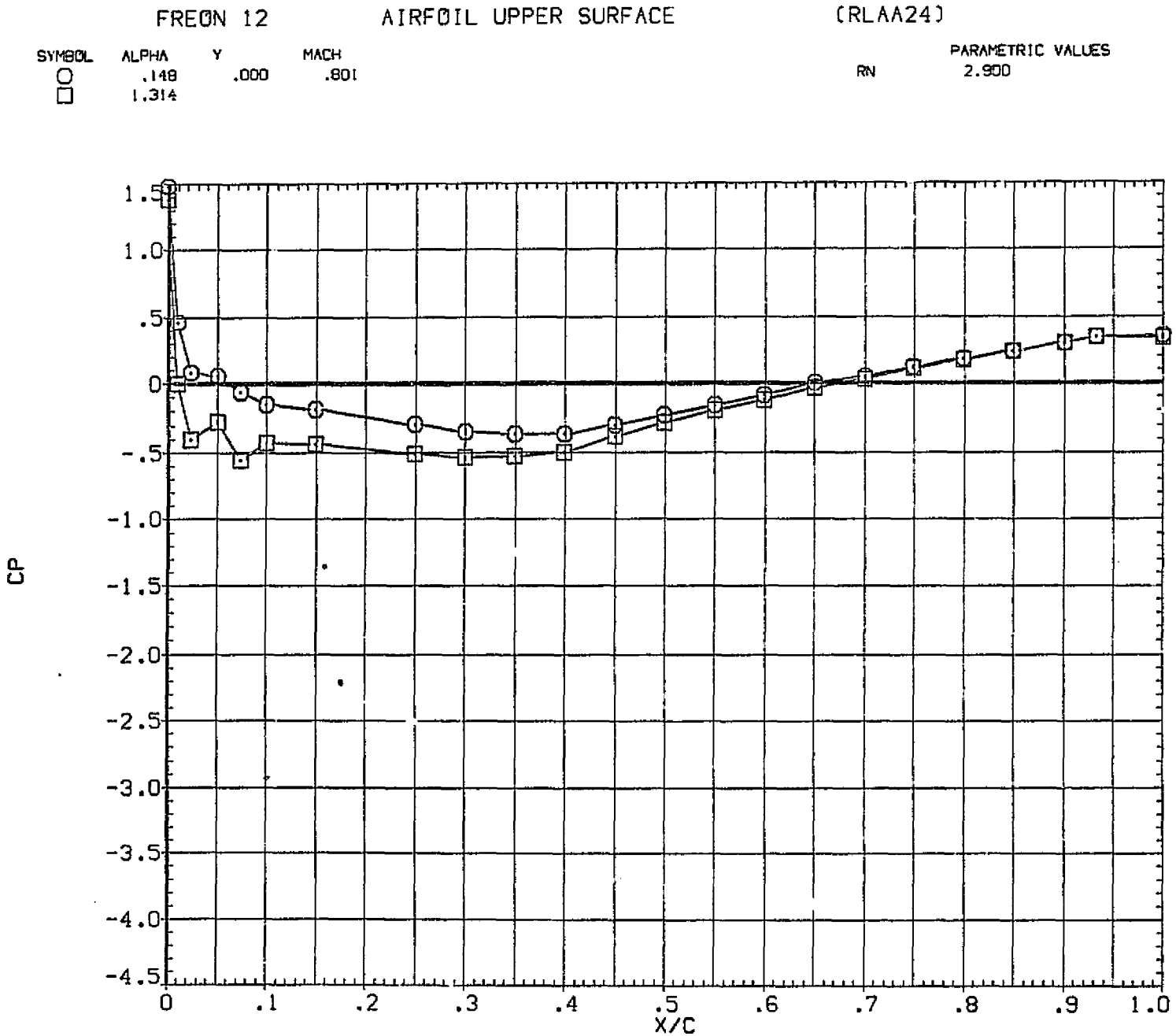

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

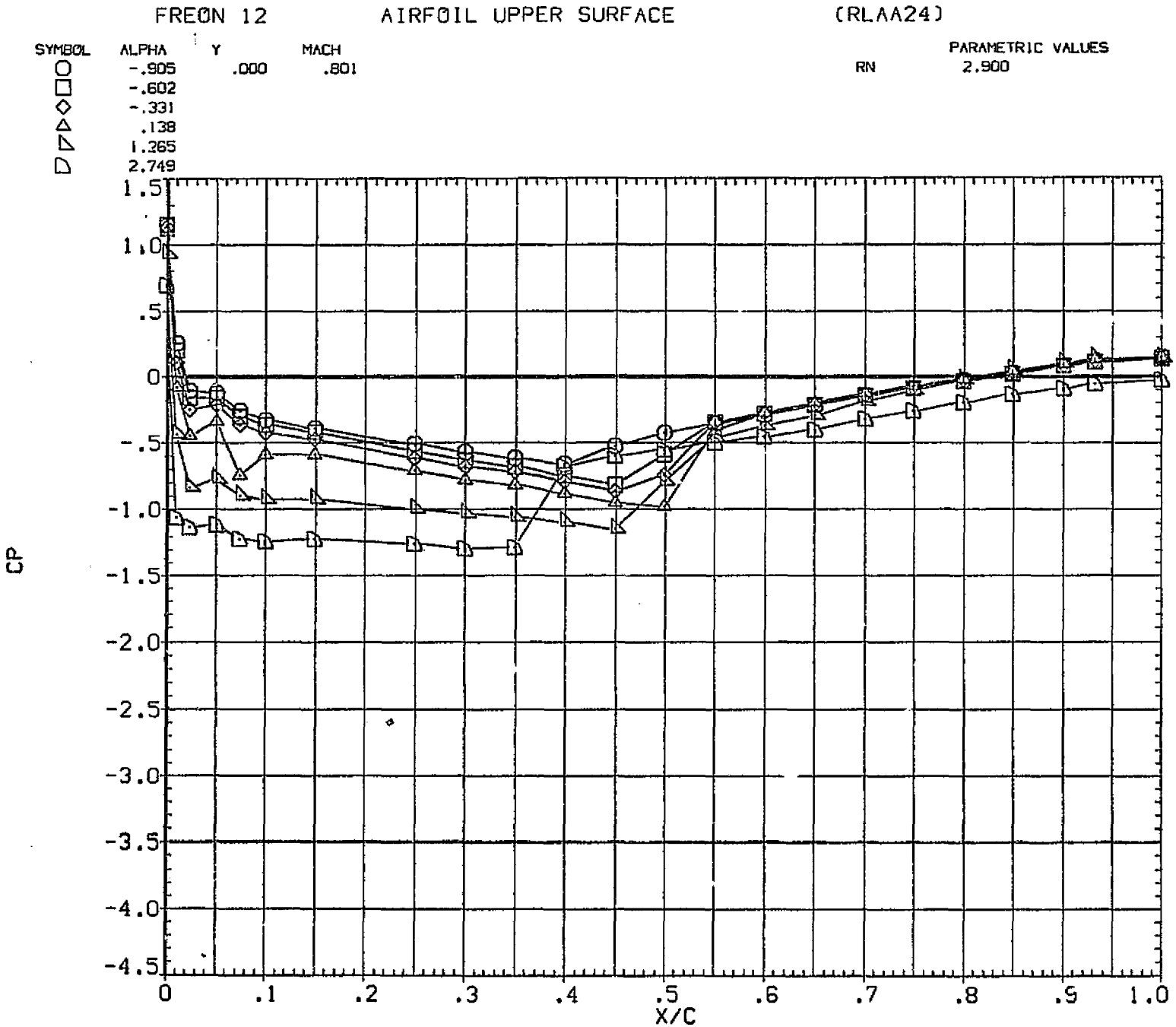

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

FREON 12 AIRFOIL UPPER SURFACE (RLAA24)

SYMBOL	ALPHA	Y	MACH
○	4.690	.000	.801
□	6.431		
◇	8.141		

PARAMETRIC VALUES
RN 2.900

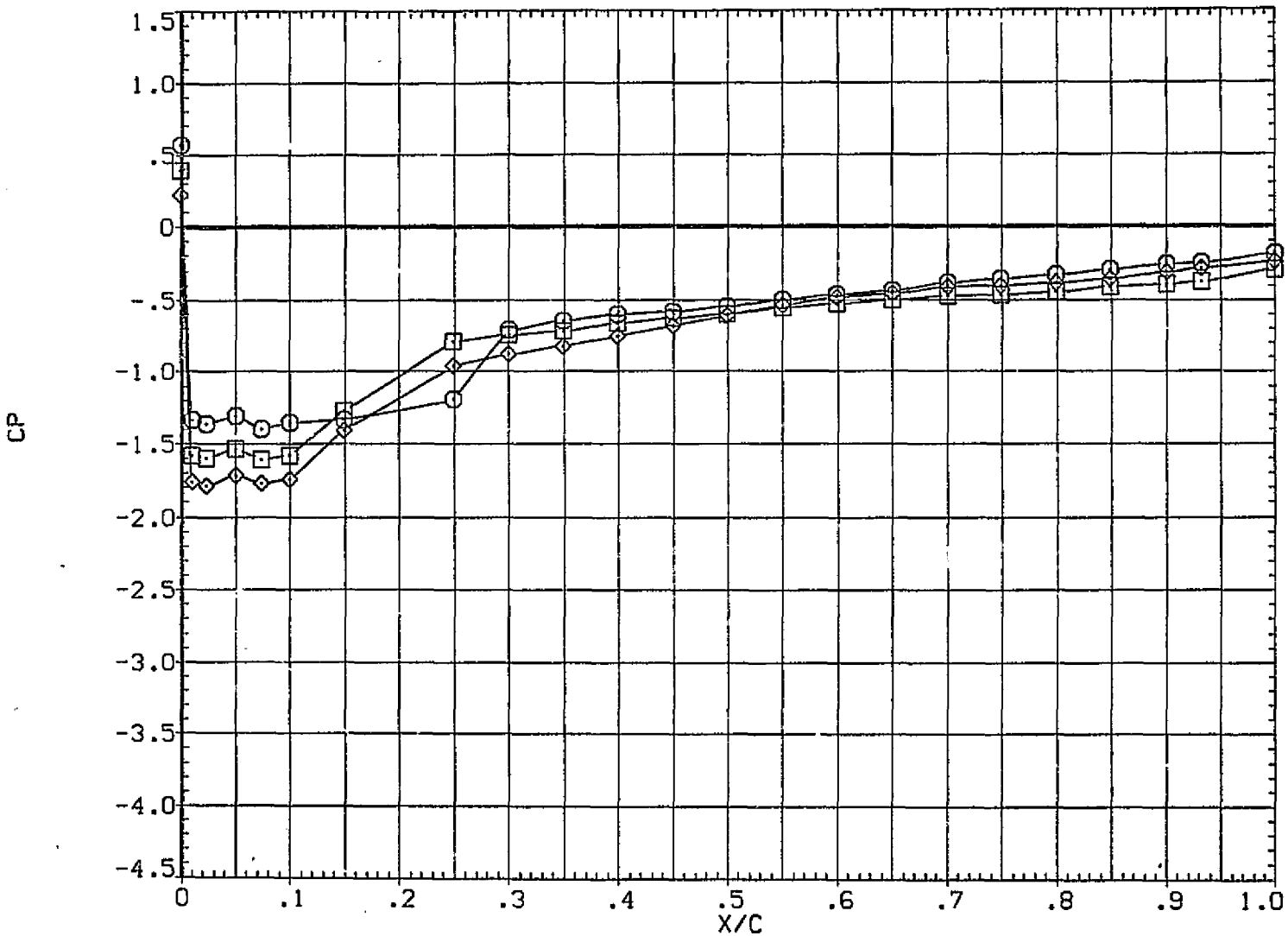

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

FREON 12 AIRFOIL UPPER SURFACE (RLAA24)

SYMBOL	ALPHA	Y	MACH
O	1.285	.000	.807

PARAMETRIC VALUES
RN 2.900

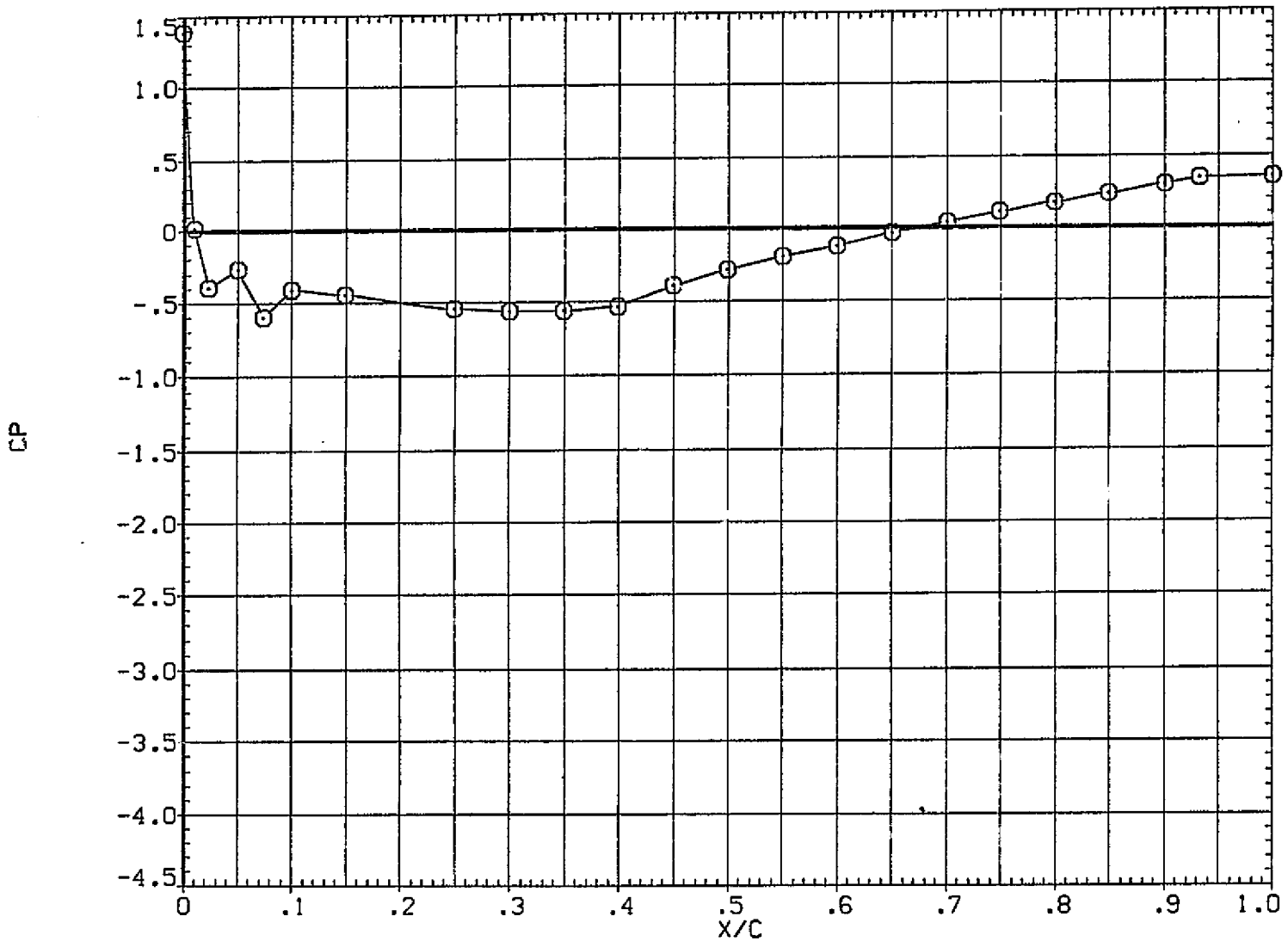

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

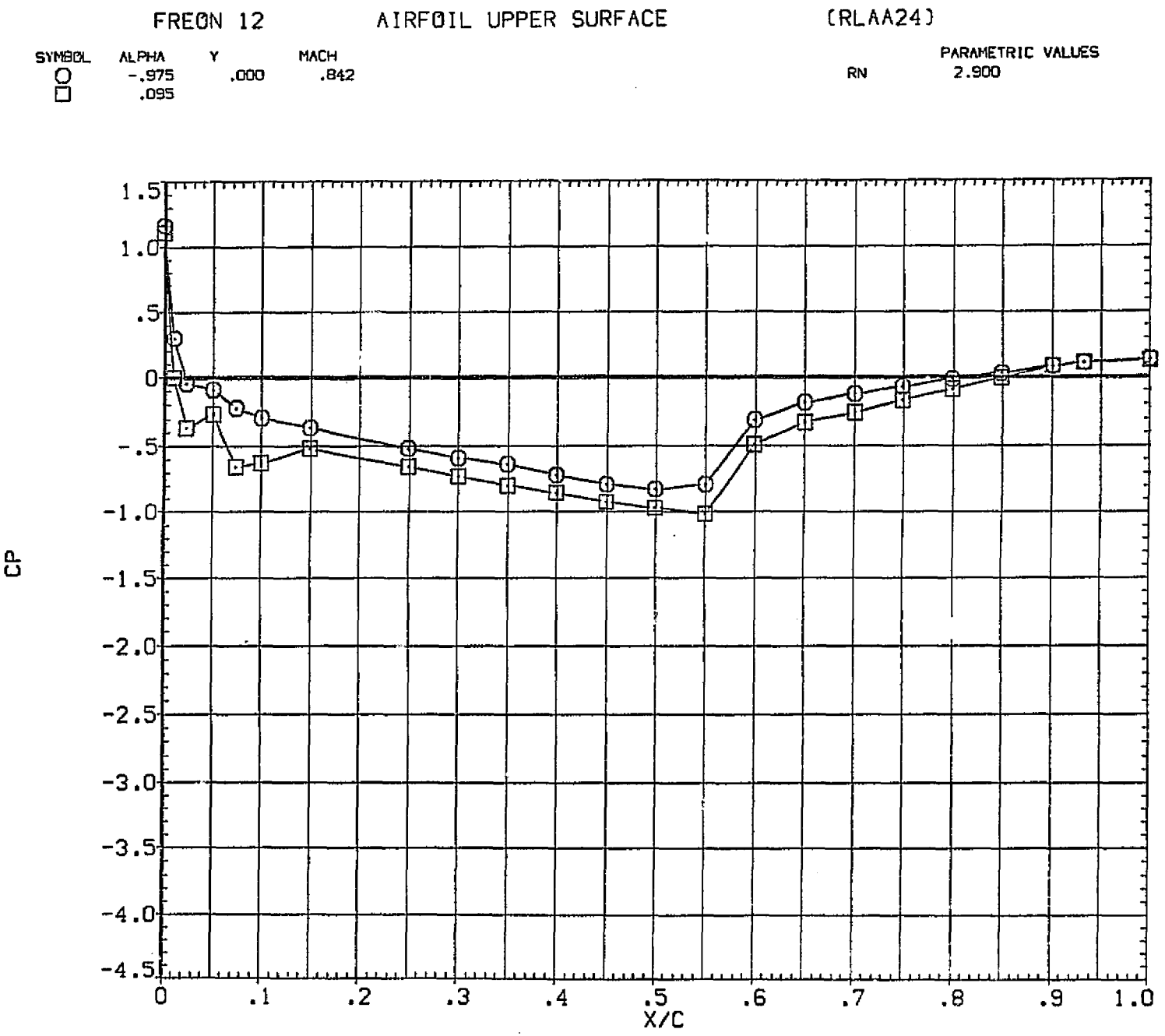

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

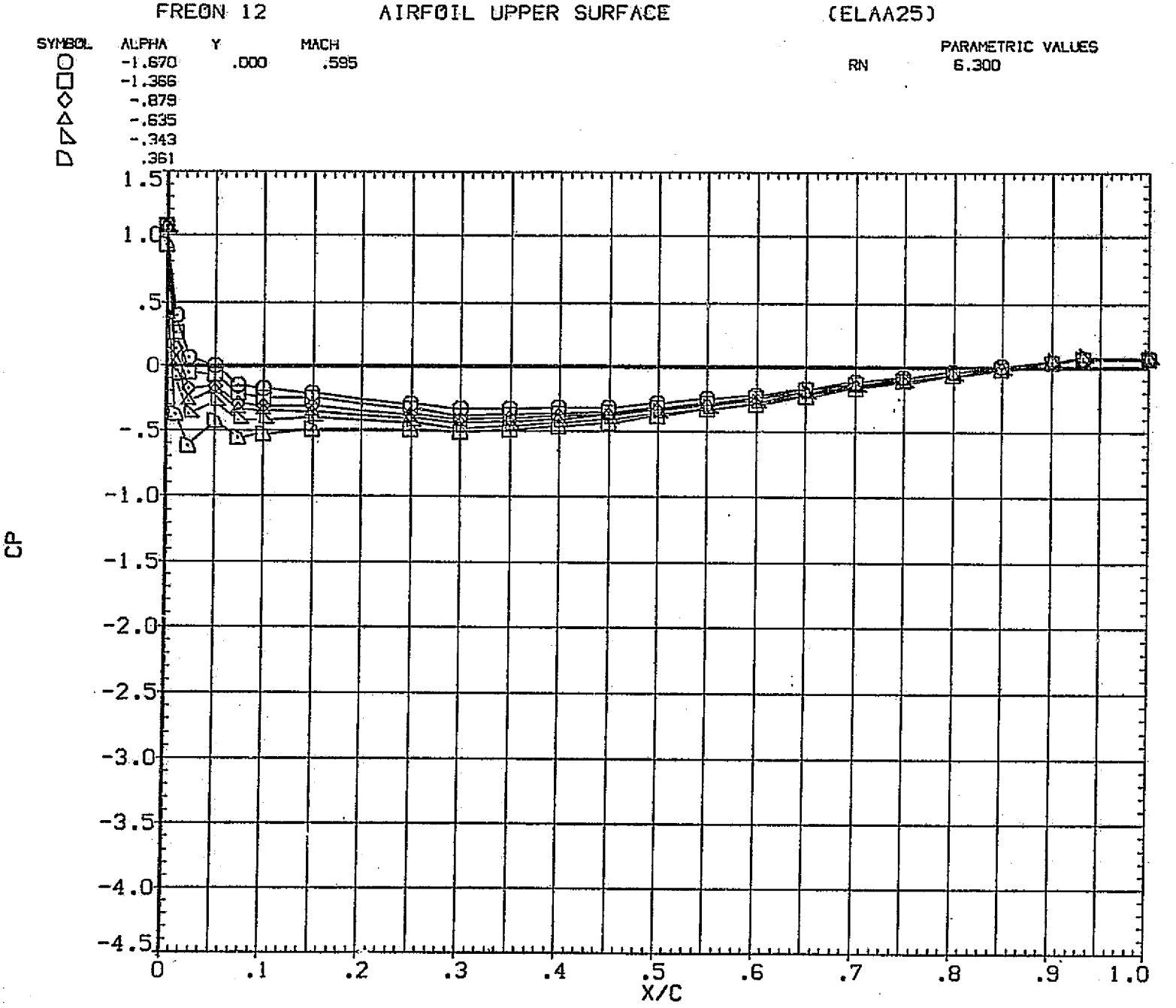

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

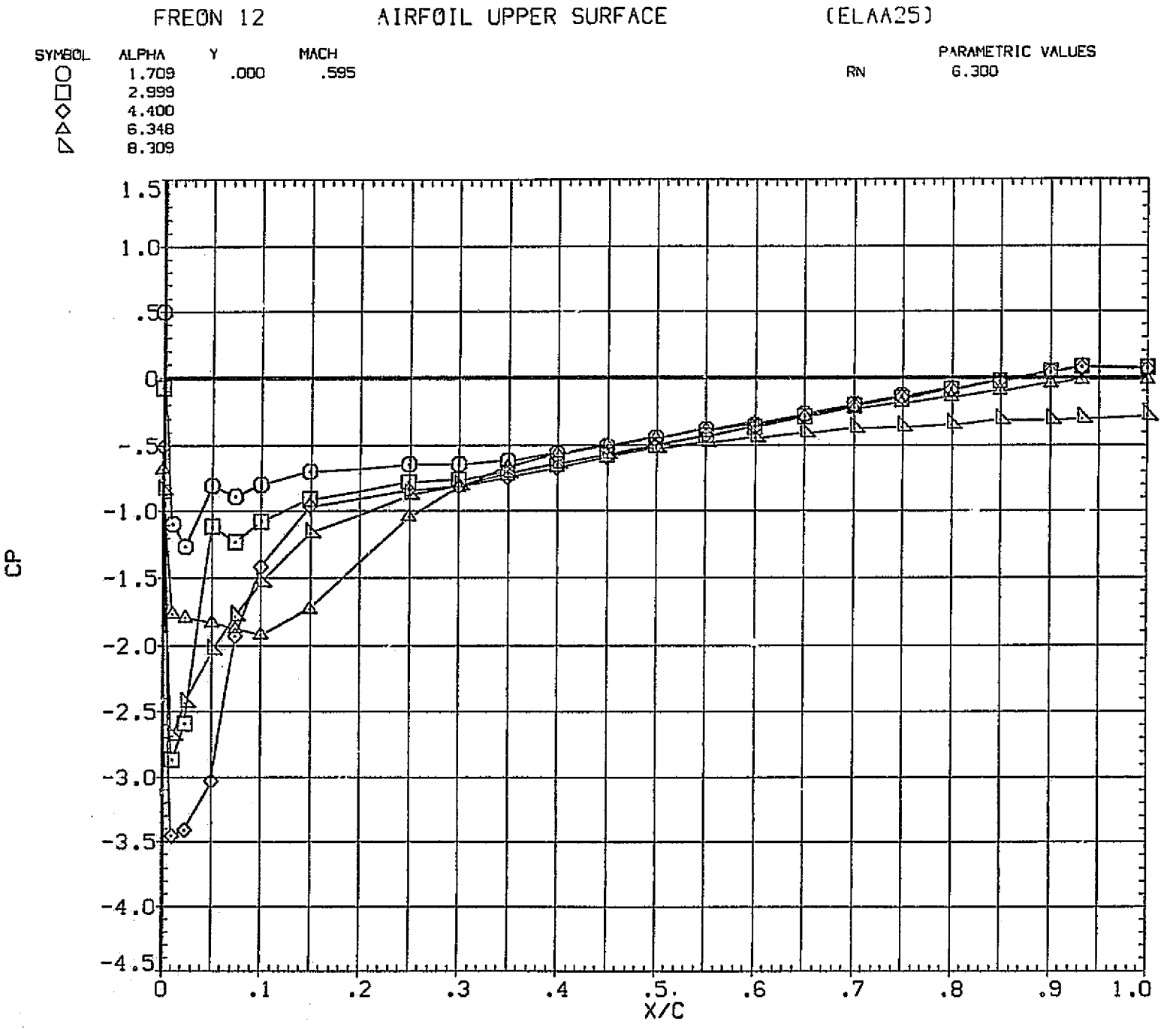

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

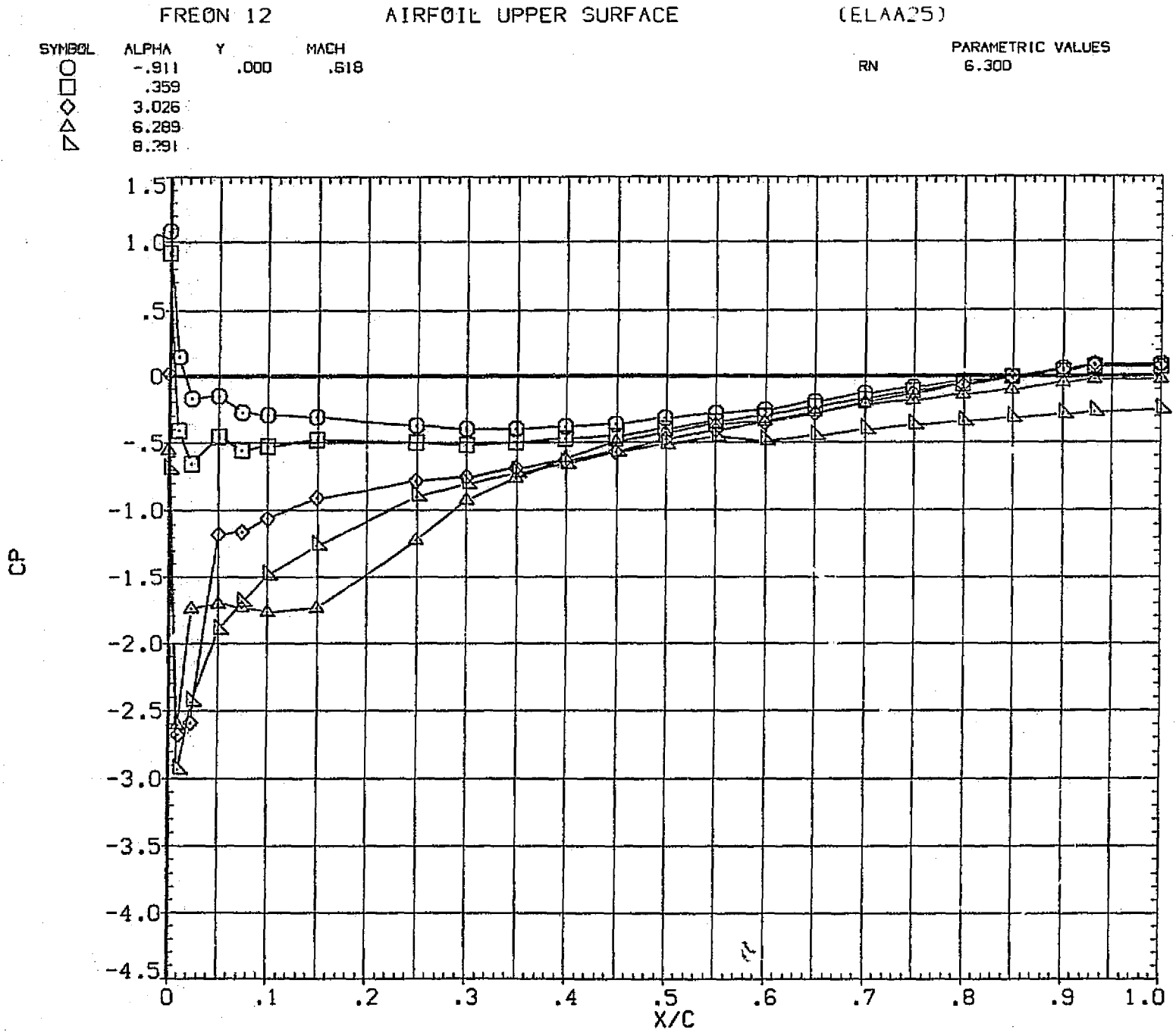

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

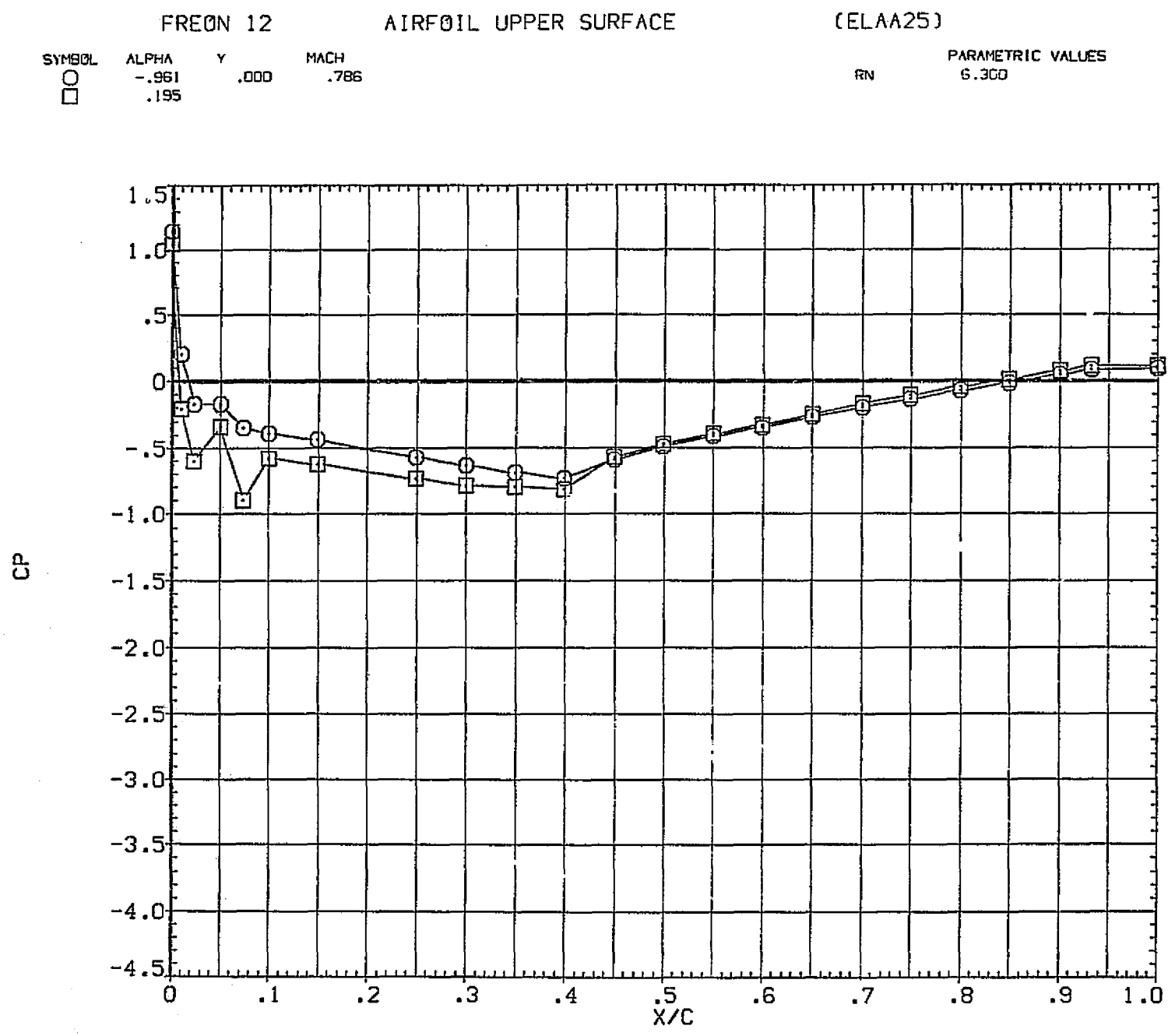

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

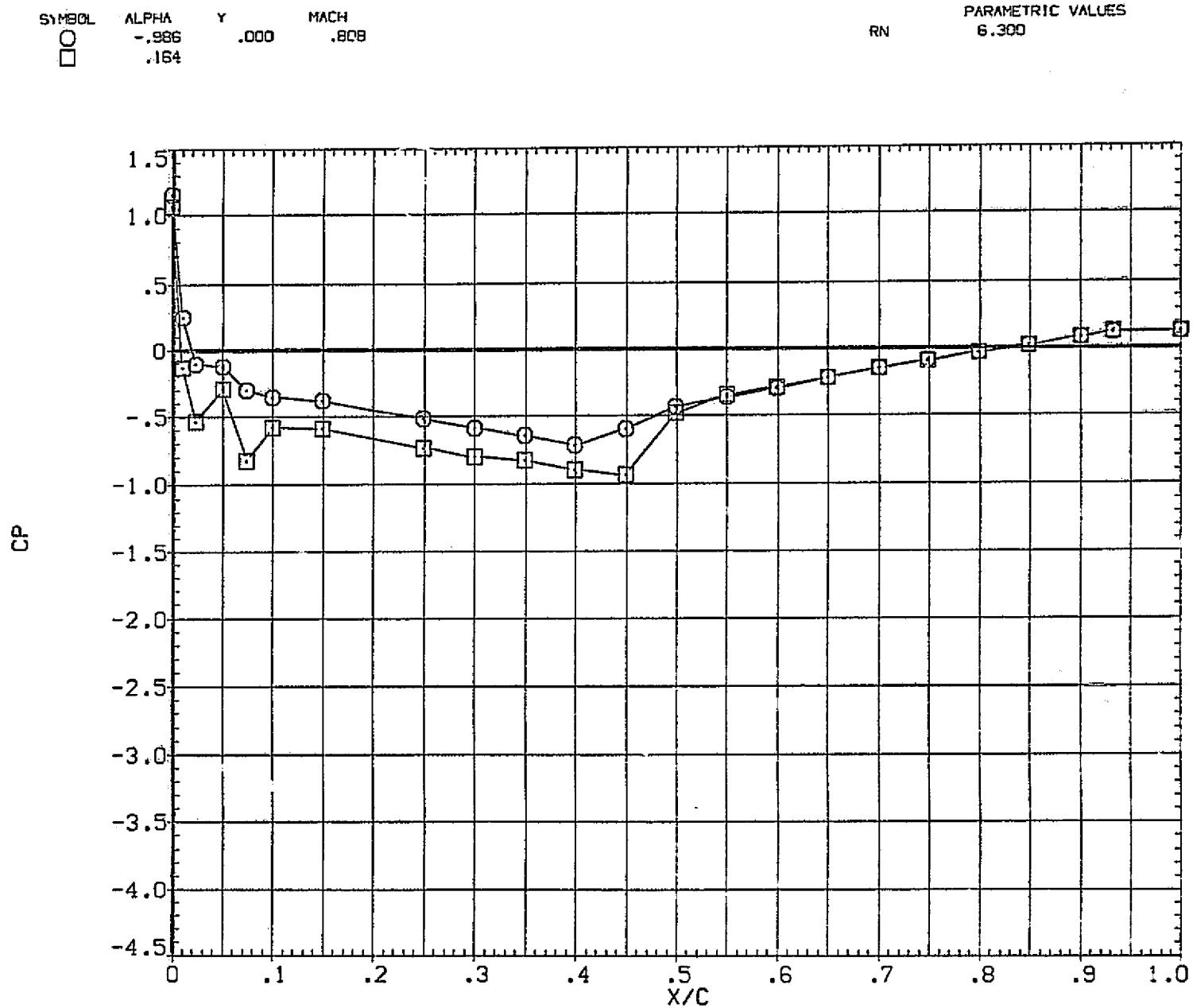

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

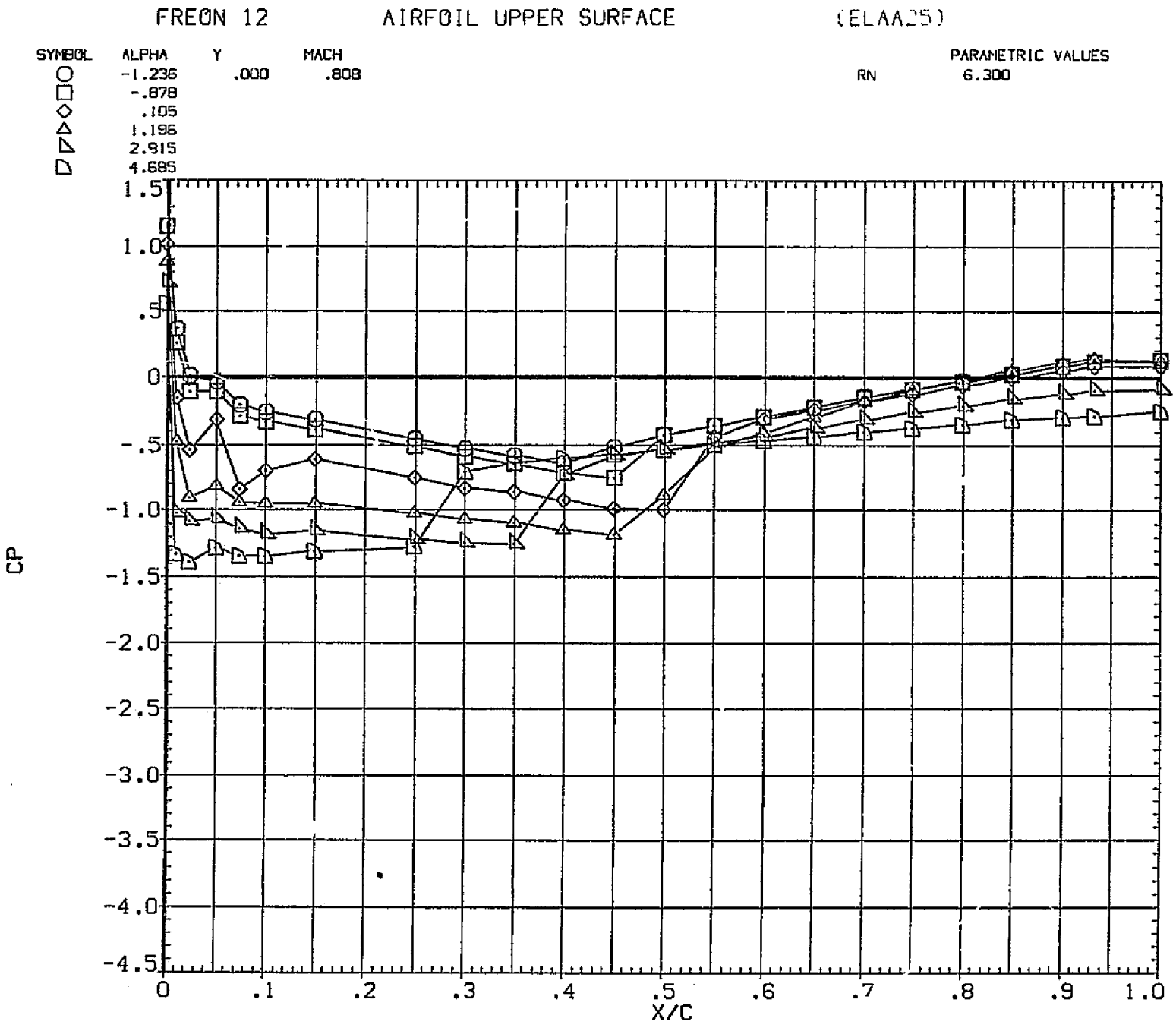

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

SYMBOL	ALPHA	Y	MACH	PARAMETRIC VALUES
○	6.400	.000	.808	RN 6.300
□	8.196			

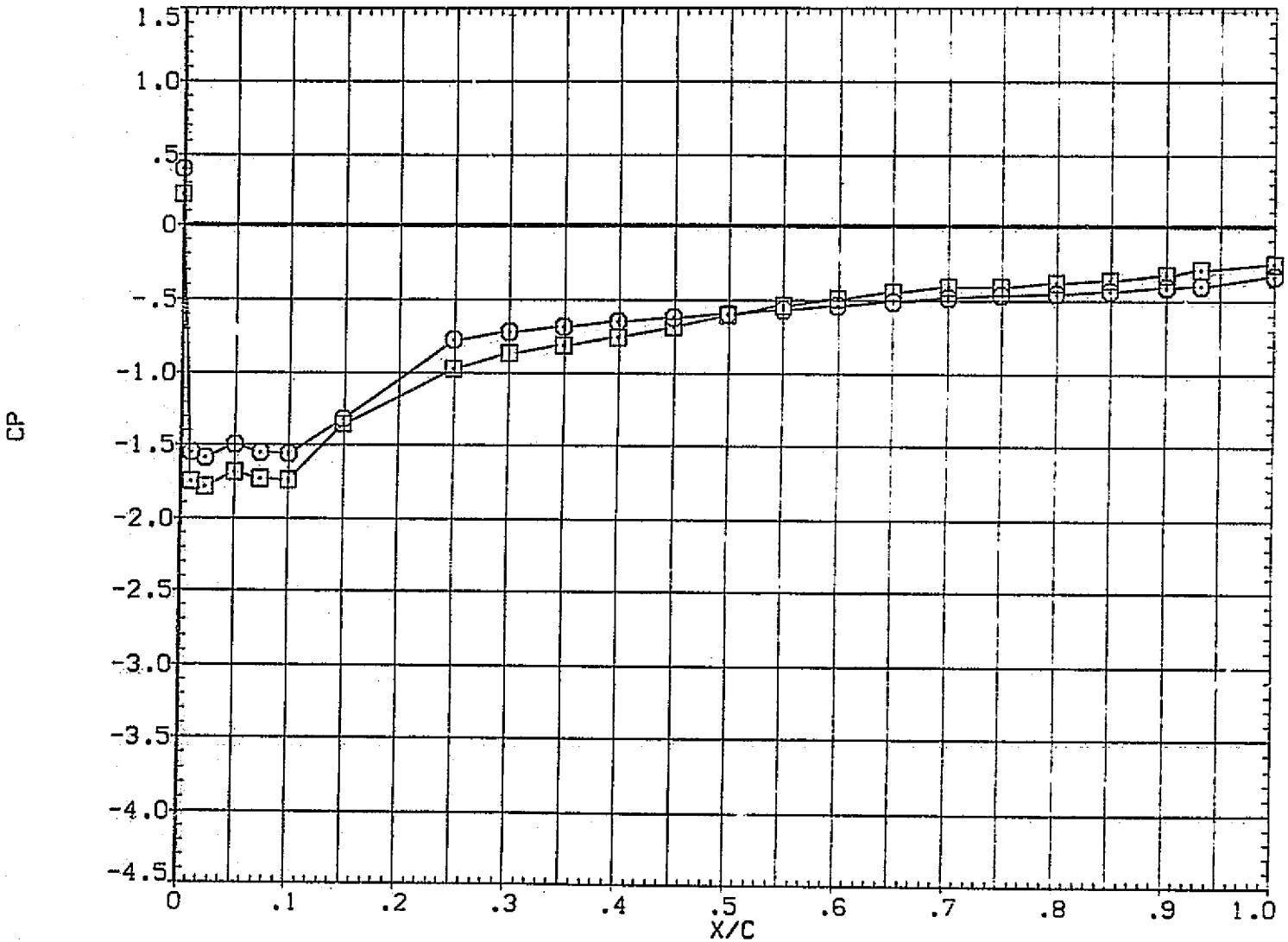

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

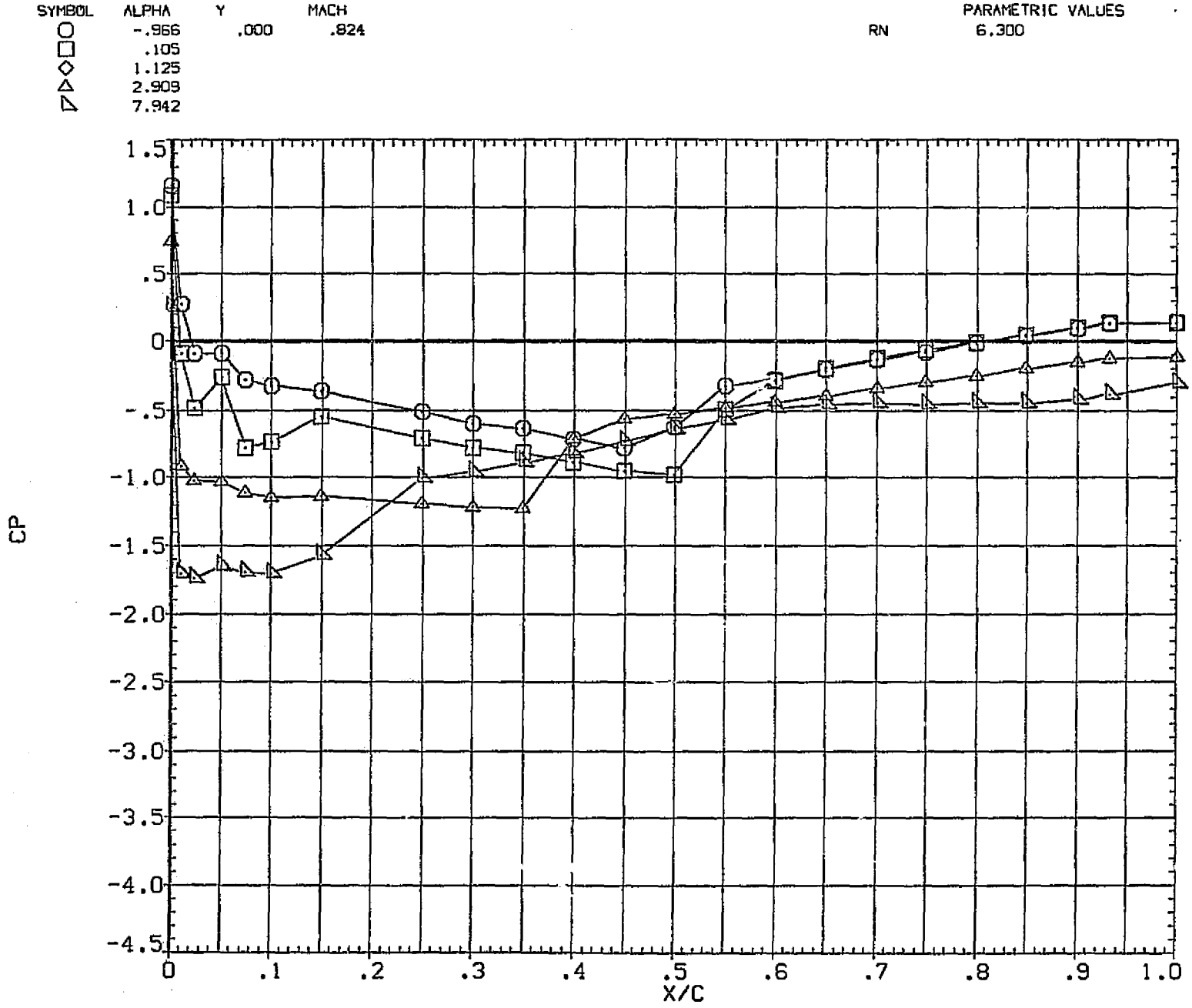

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

SYMBOL	ALPHA	Y	MACH
○	-.994	.000	.851
□	.063		

PARAMETRIC VALUES
RN 6.300

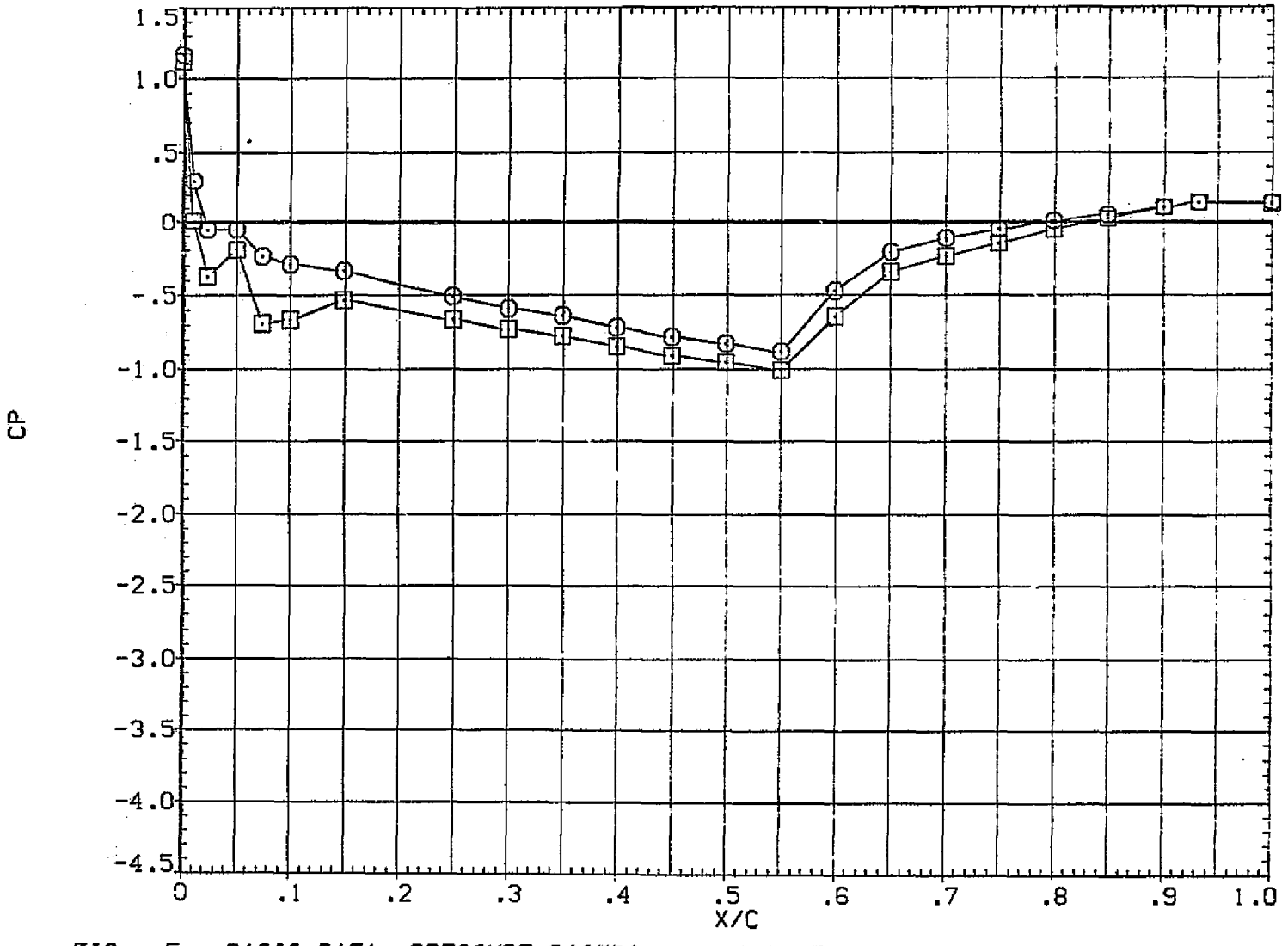

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

FREON 12 AIRFOIL UPPER SURFACE (ELAA25)

SYMBOL	ALPHA	Y	MACH
○	-1.103	.000	.895
□	.844		

PARAMETRIC VALUES

RN 6.300

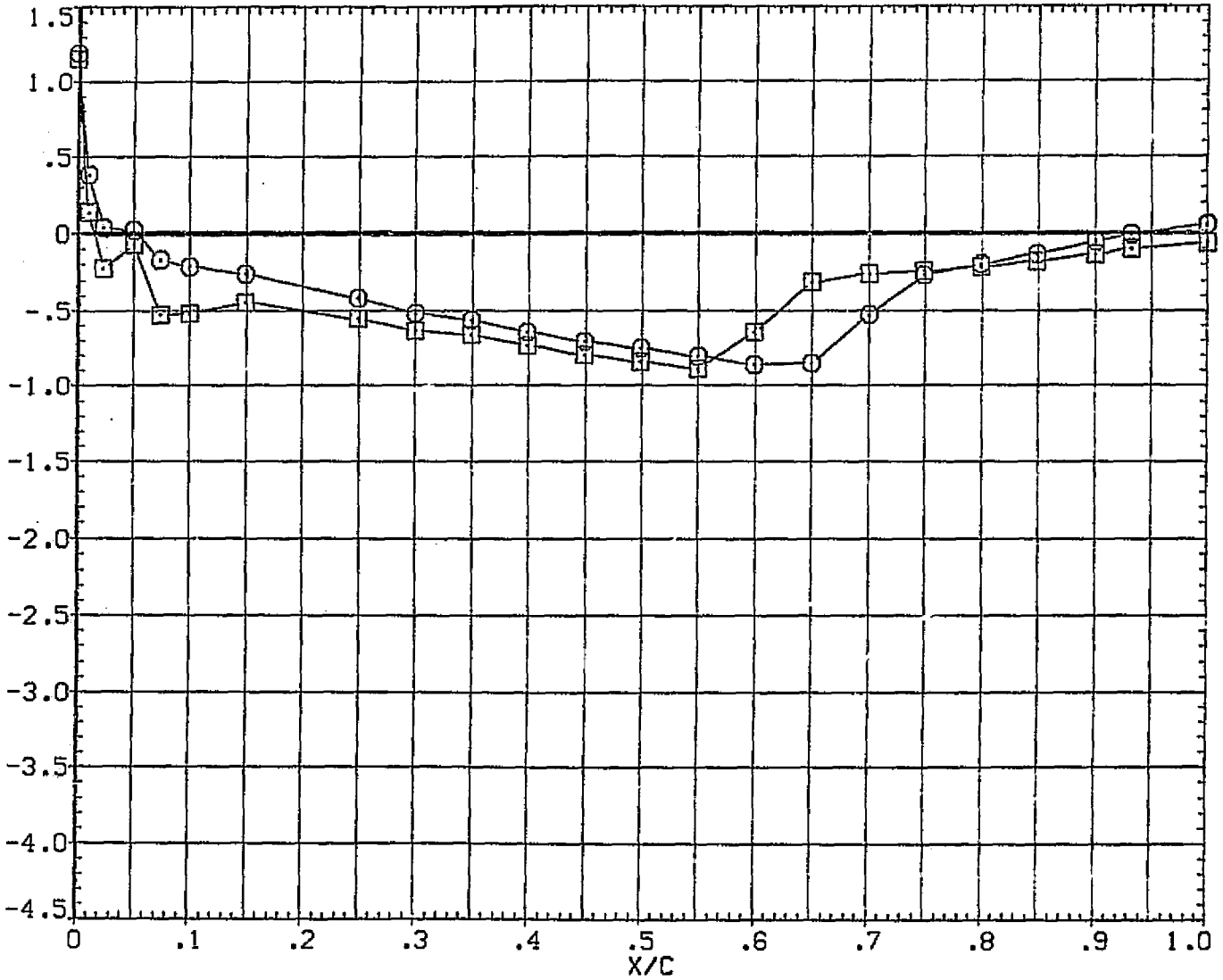

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

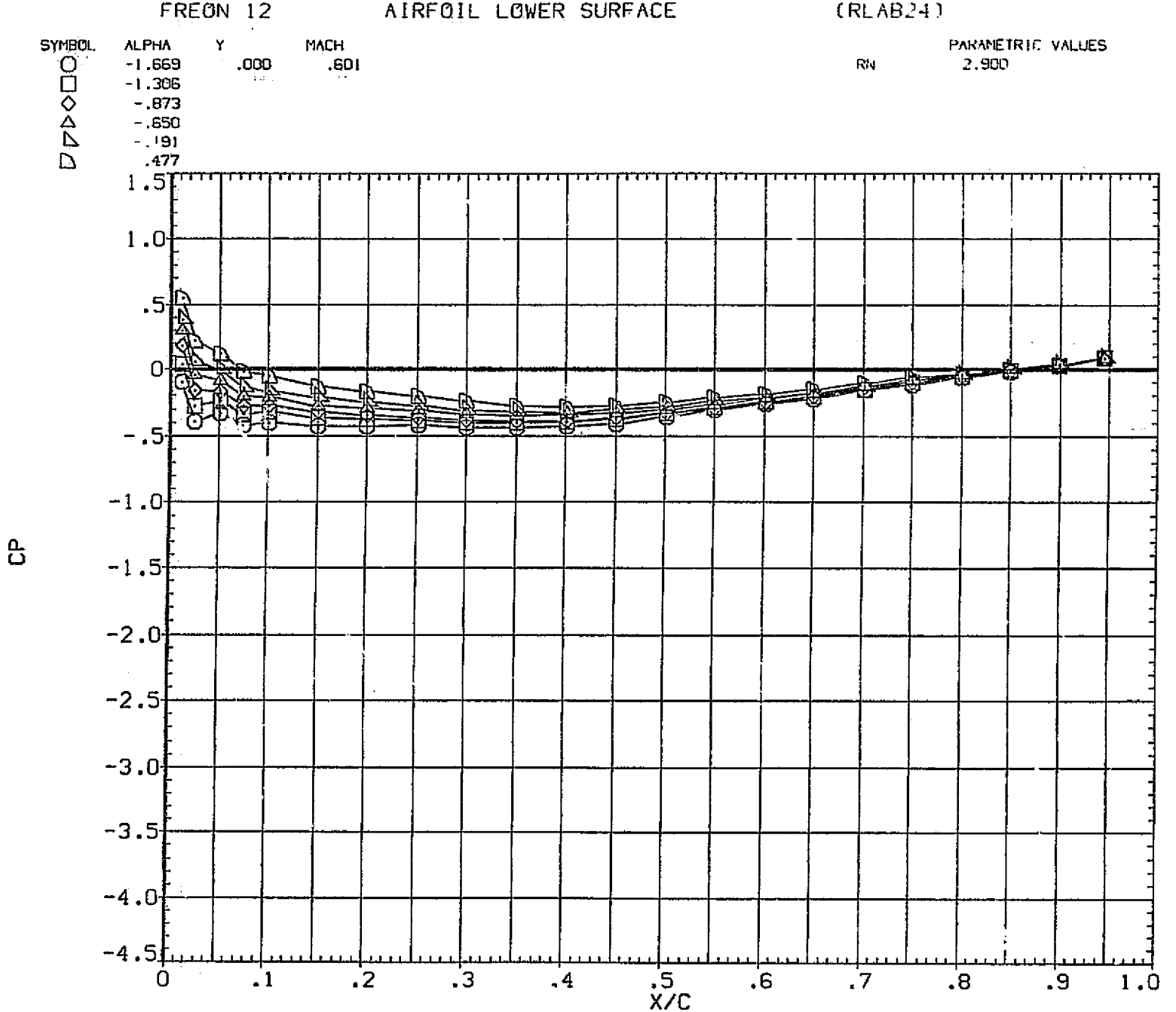

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

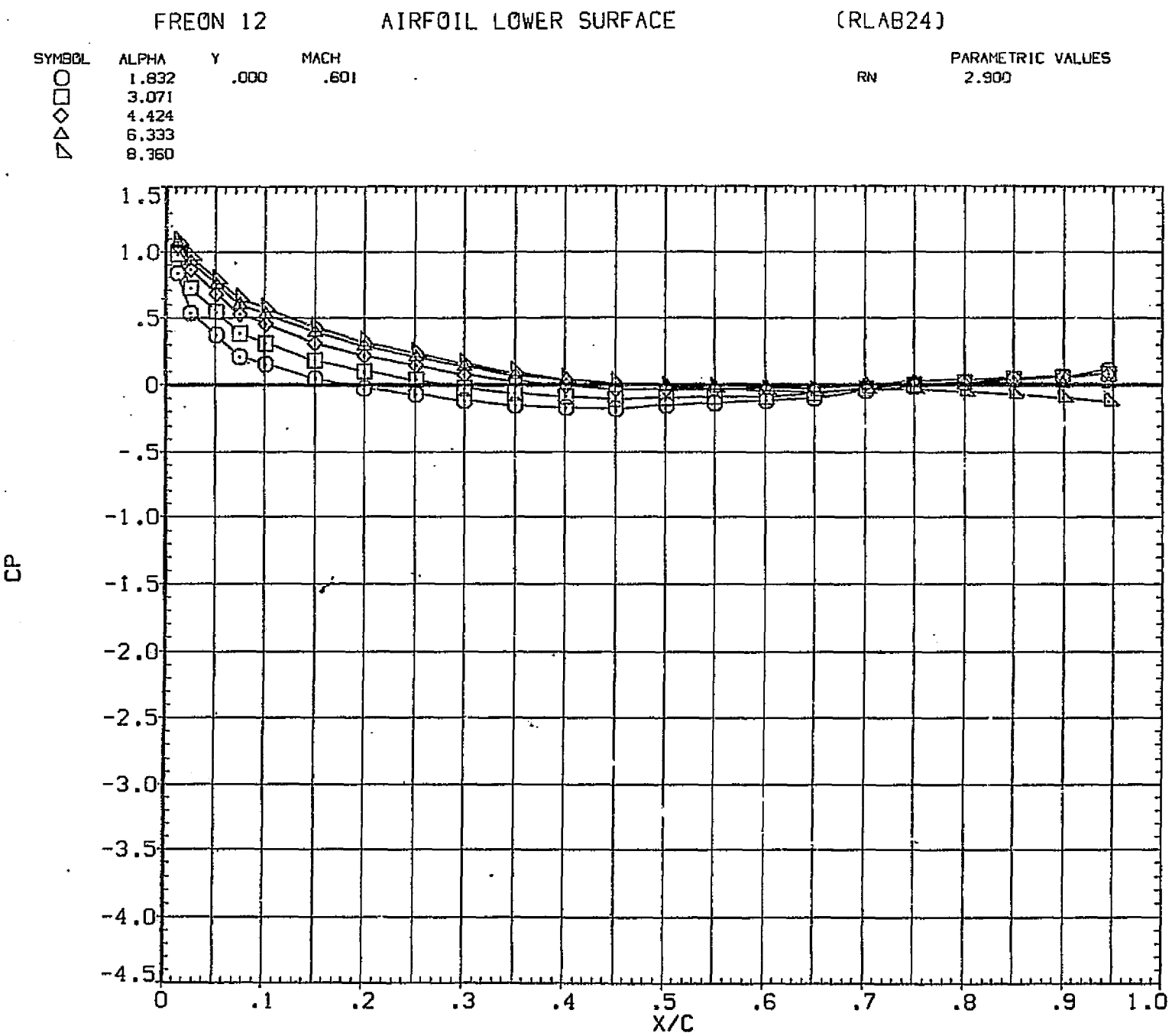

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

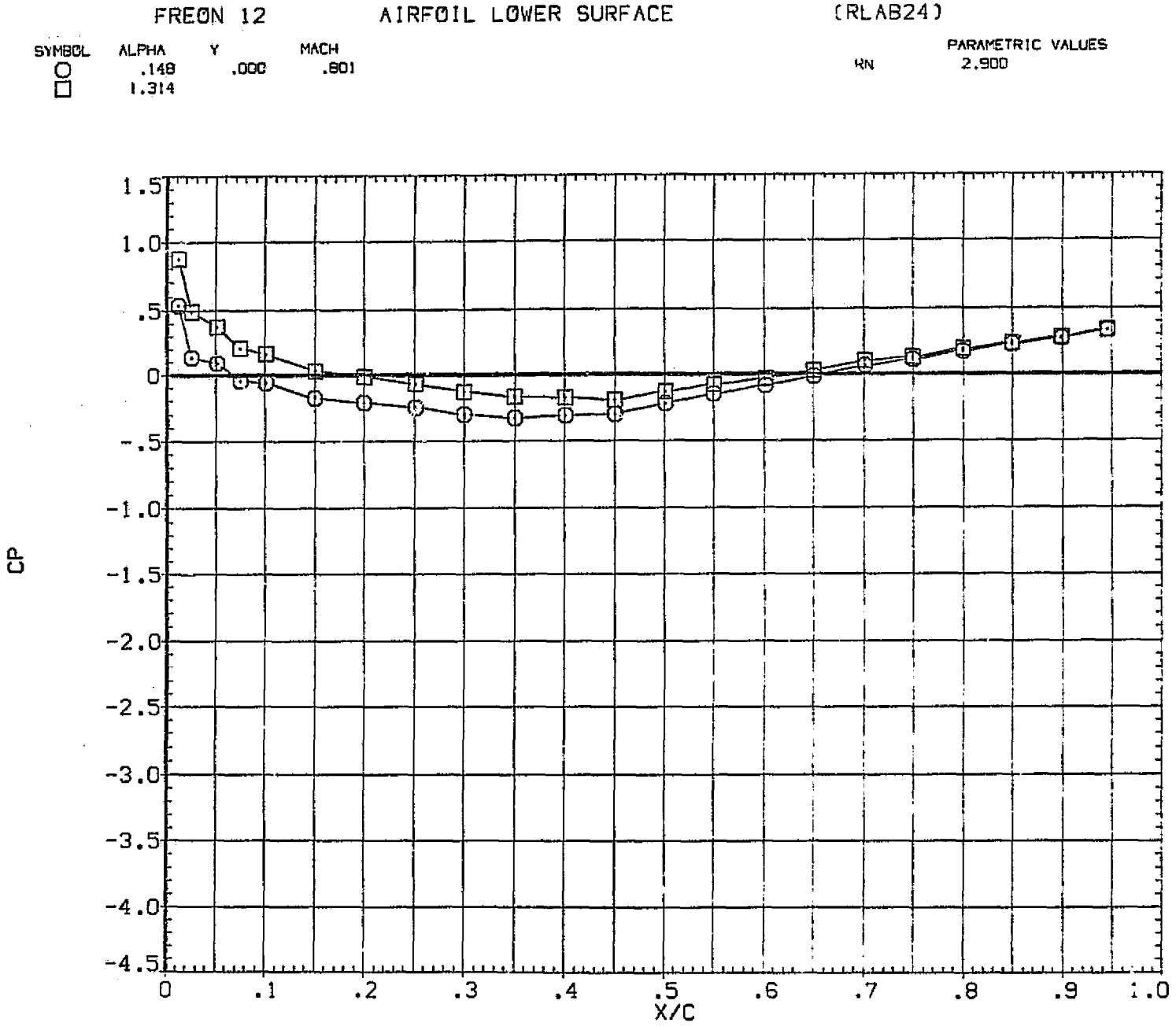

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

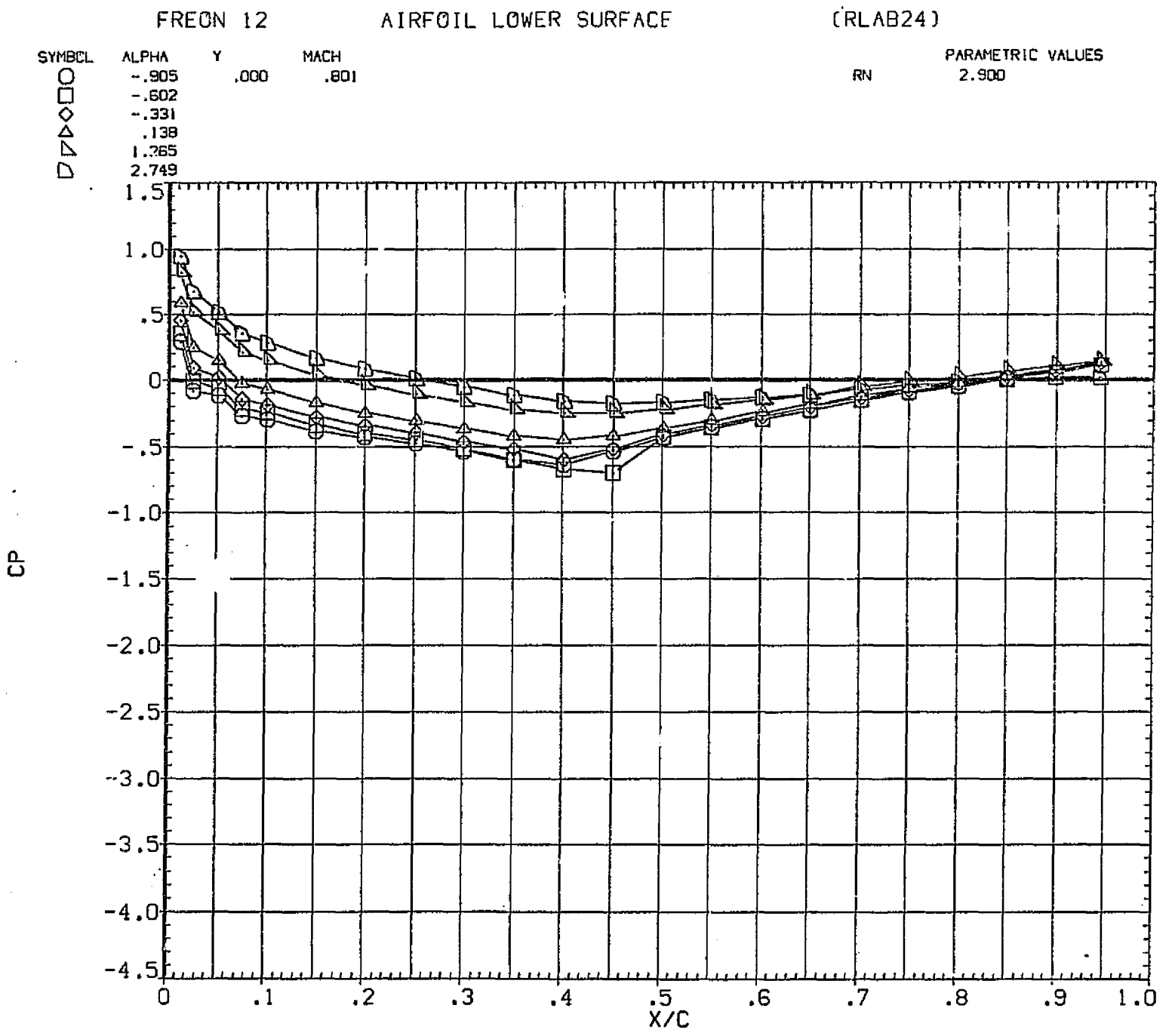

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

SYMBOL	ALPHA	Y	MACH
○	4.690	.000	.801
□	6.431		
◇	8.141		

PARAMETRIC VALUES
RN 2.900

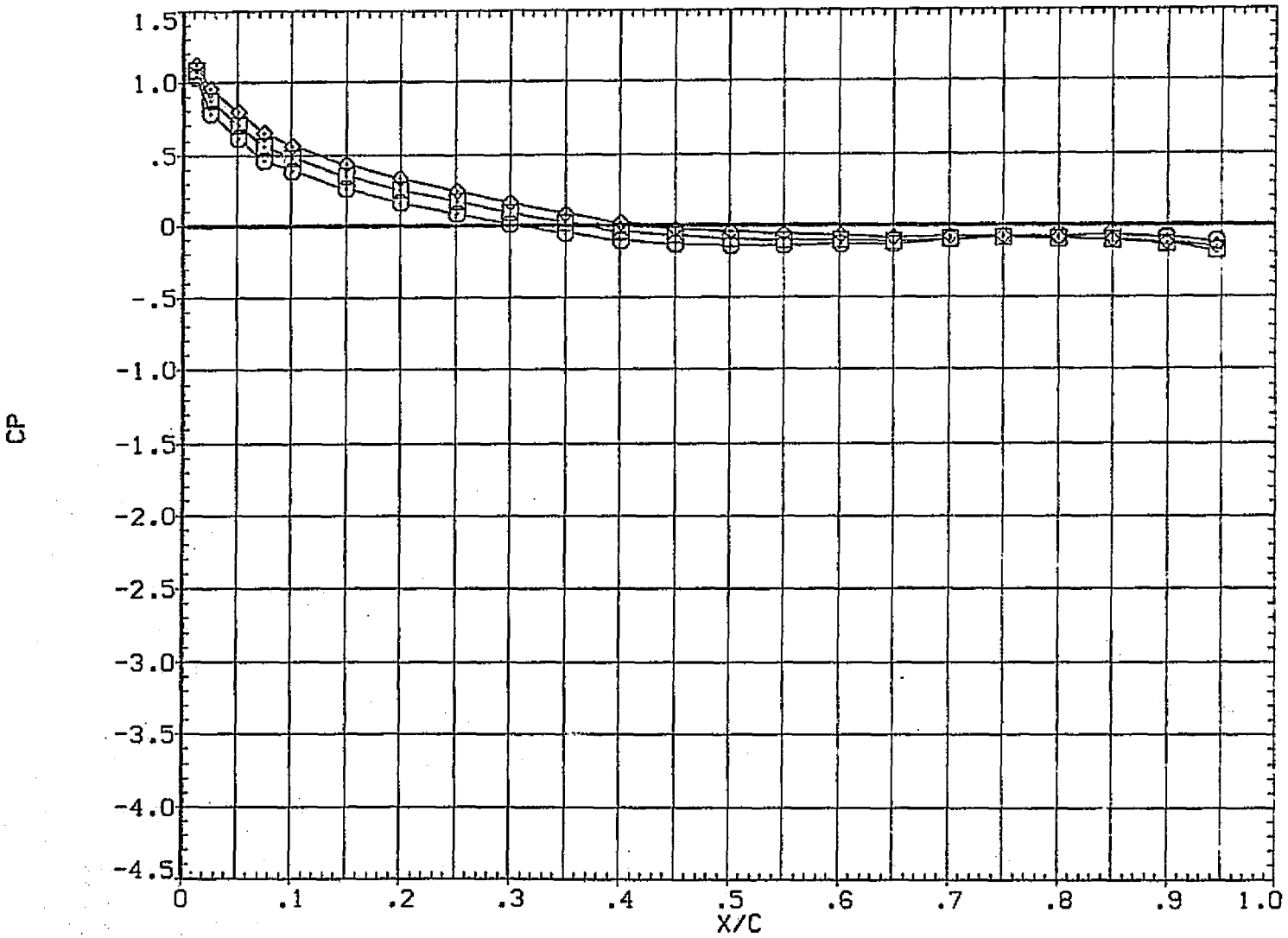

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

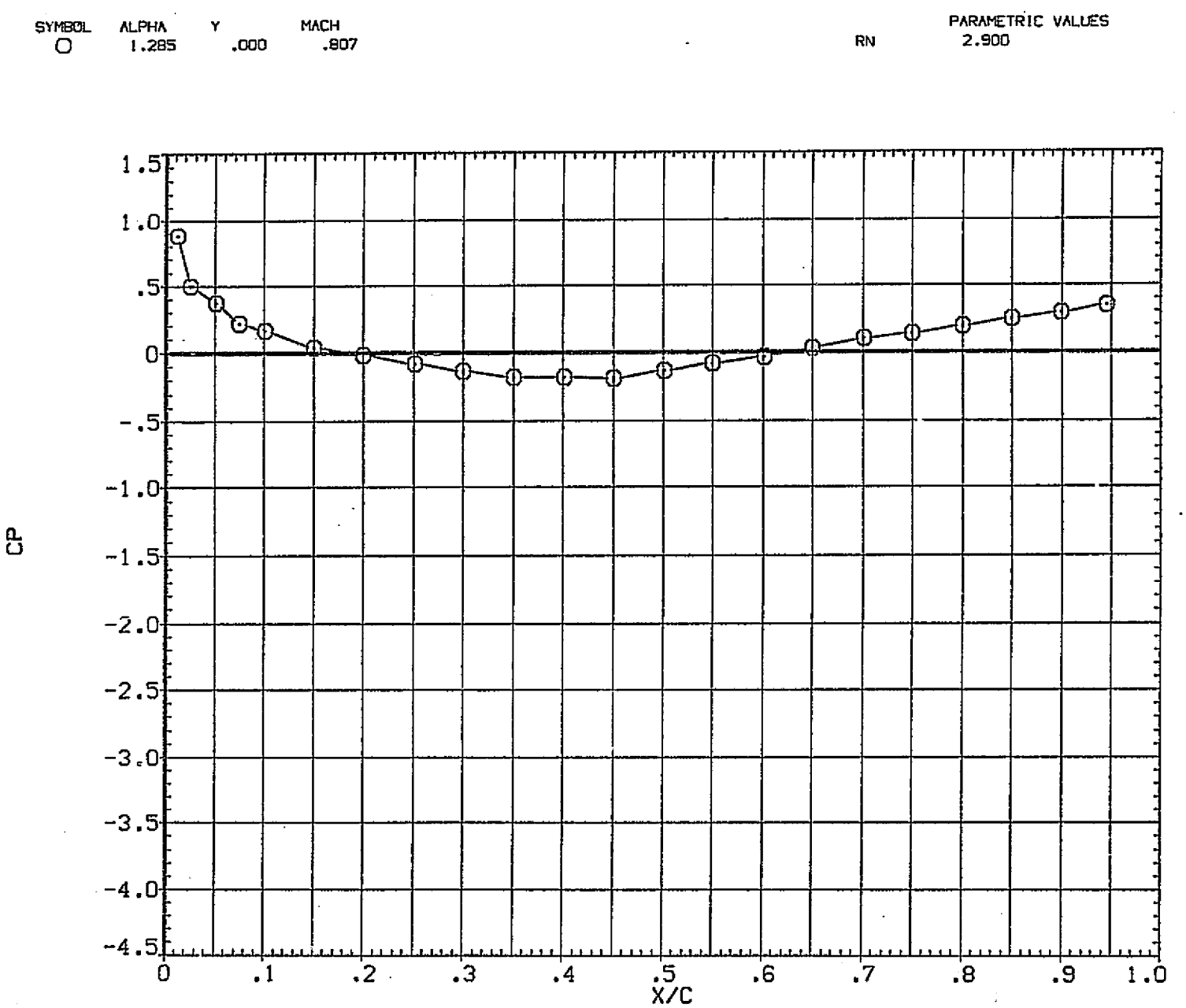

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

SYMBOL	ALPHA	Y	MACH
○	-.975	.000	.842
□	.095		

PARAMETRIC VALUES
RN 2.900

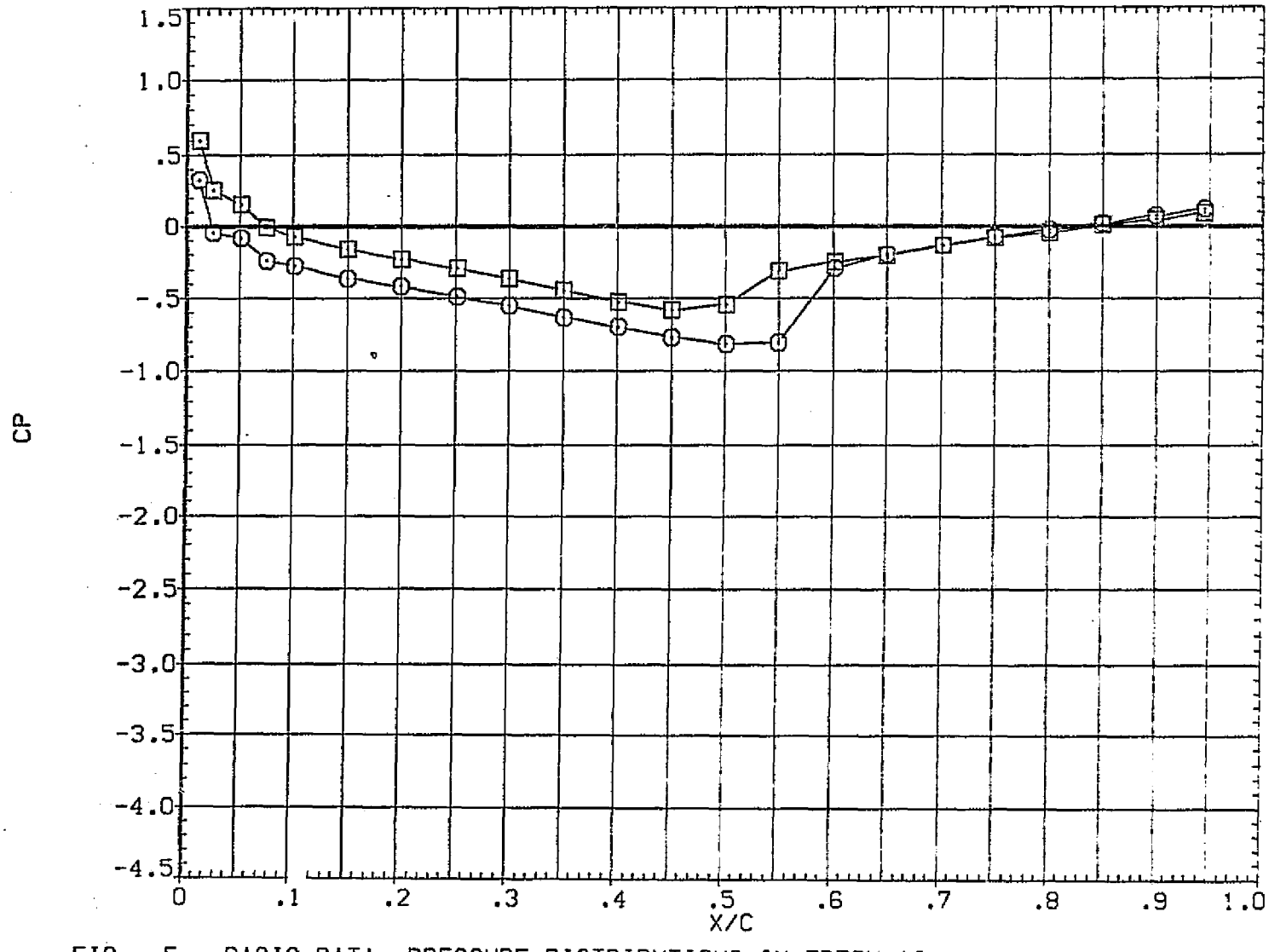

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

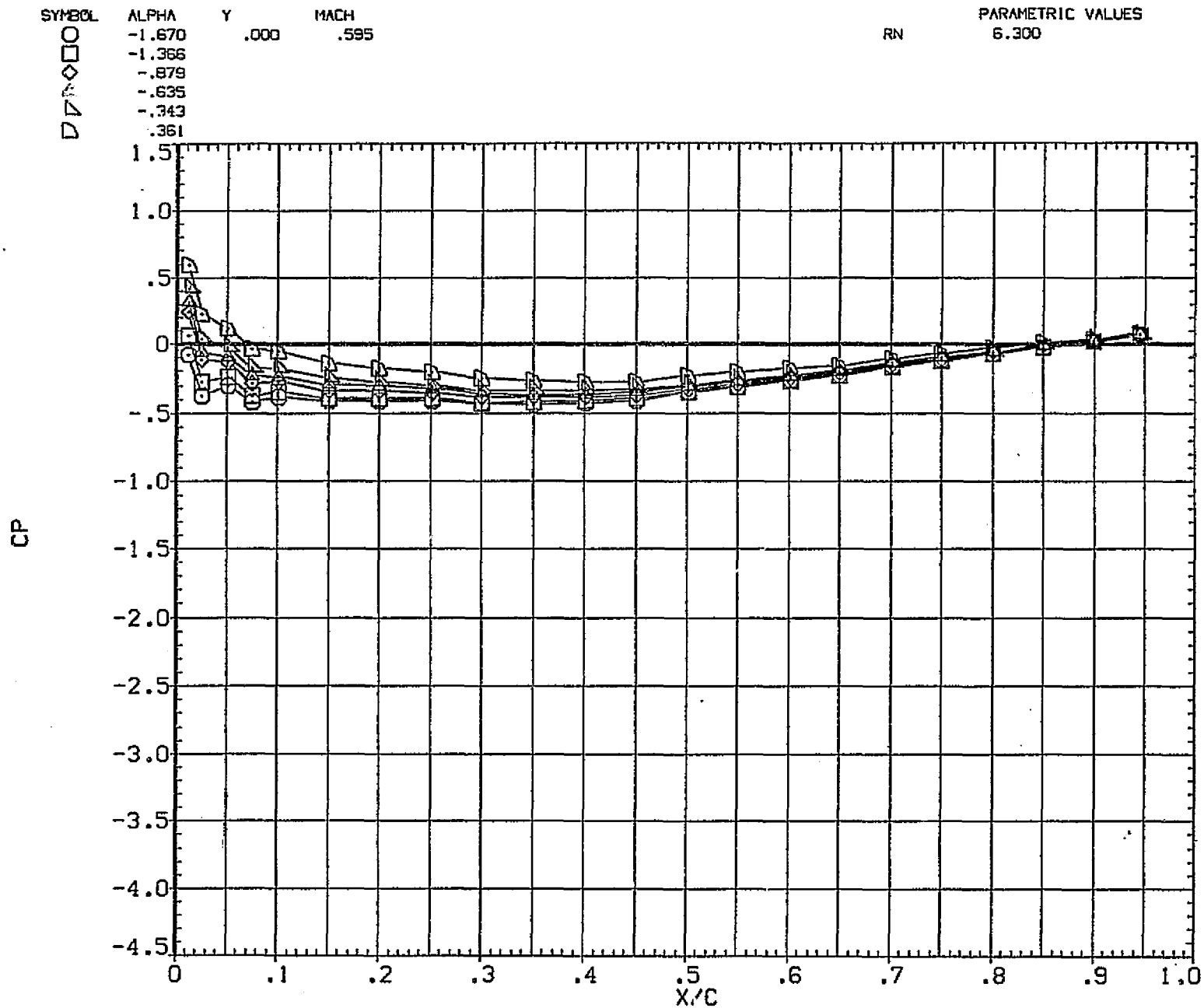

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

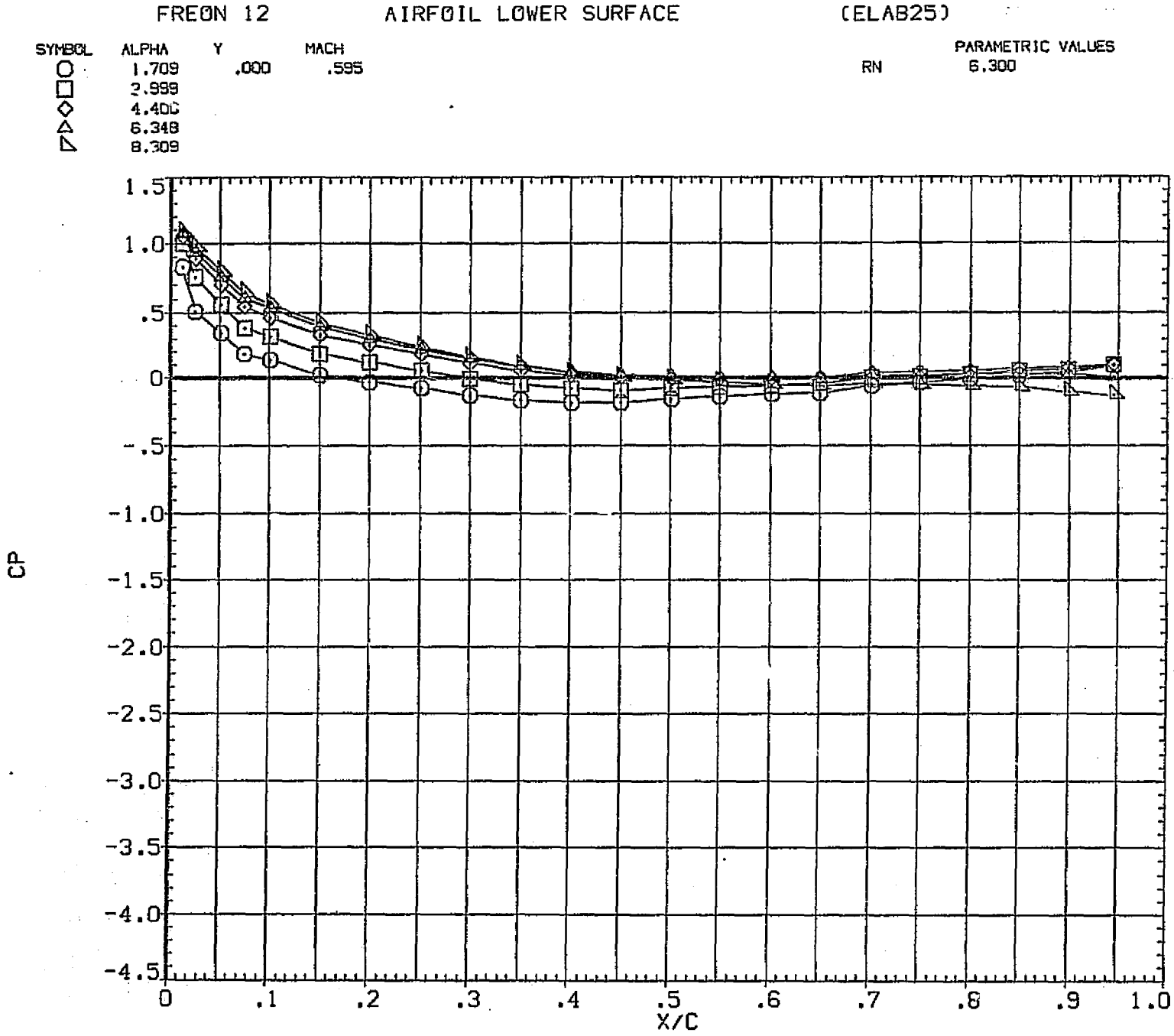

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

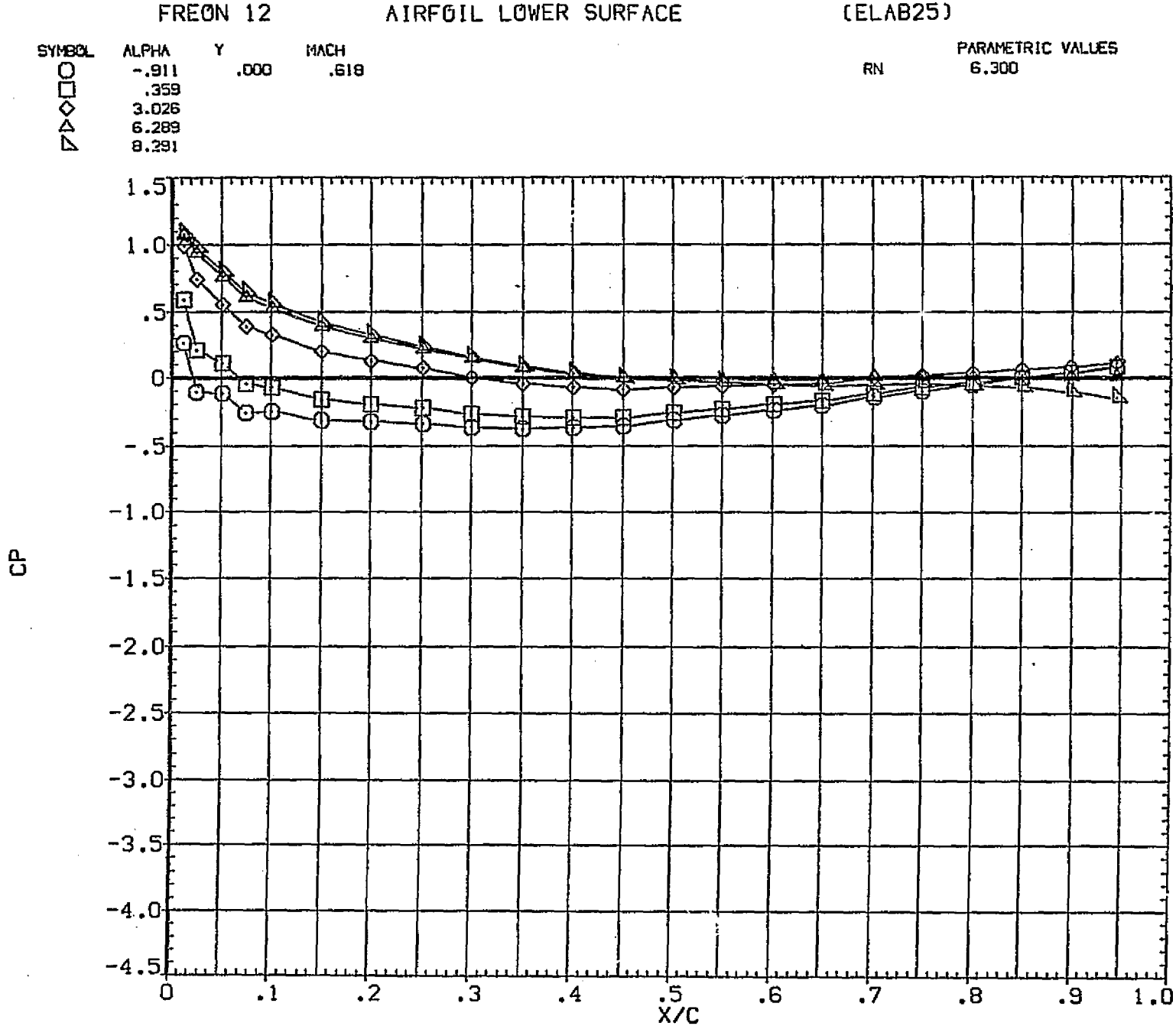

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

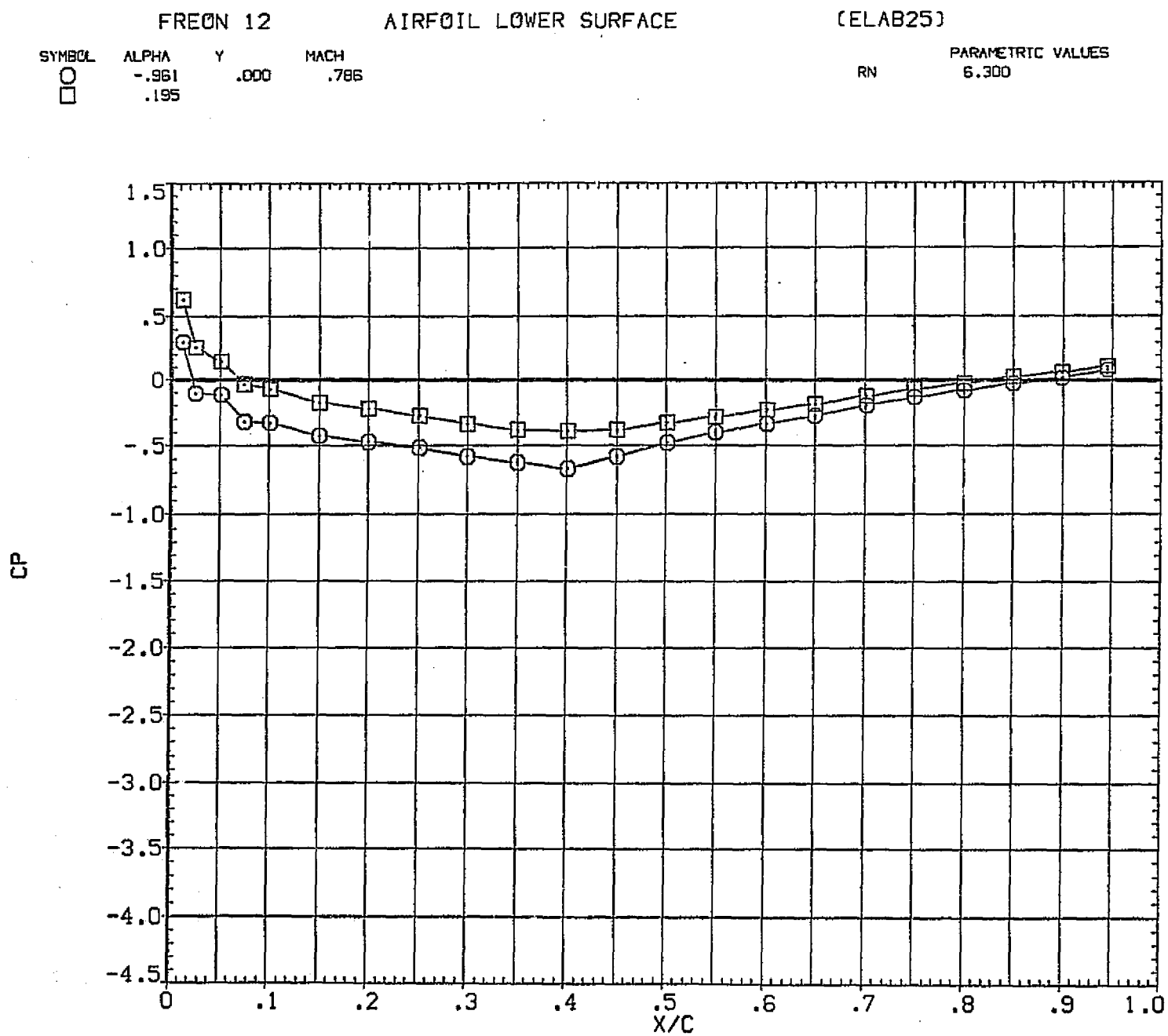

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

FREON 12 AIRFOIL LOWER SURFACE (ELAB2S)

SYMBOL	ALPHA	Y	MACH
○	-.966	.000	.808
□	.164		

PARAMETRIC VALUES

RN 6.300

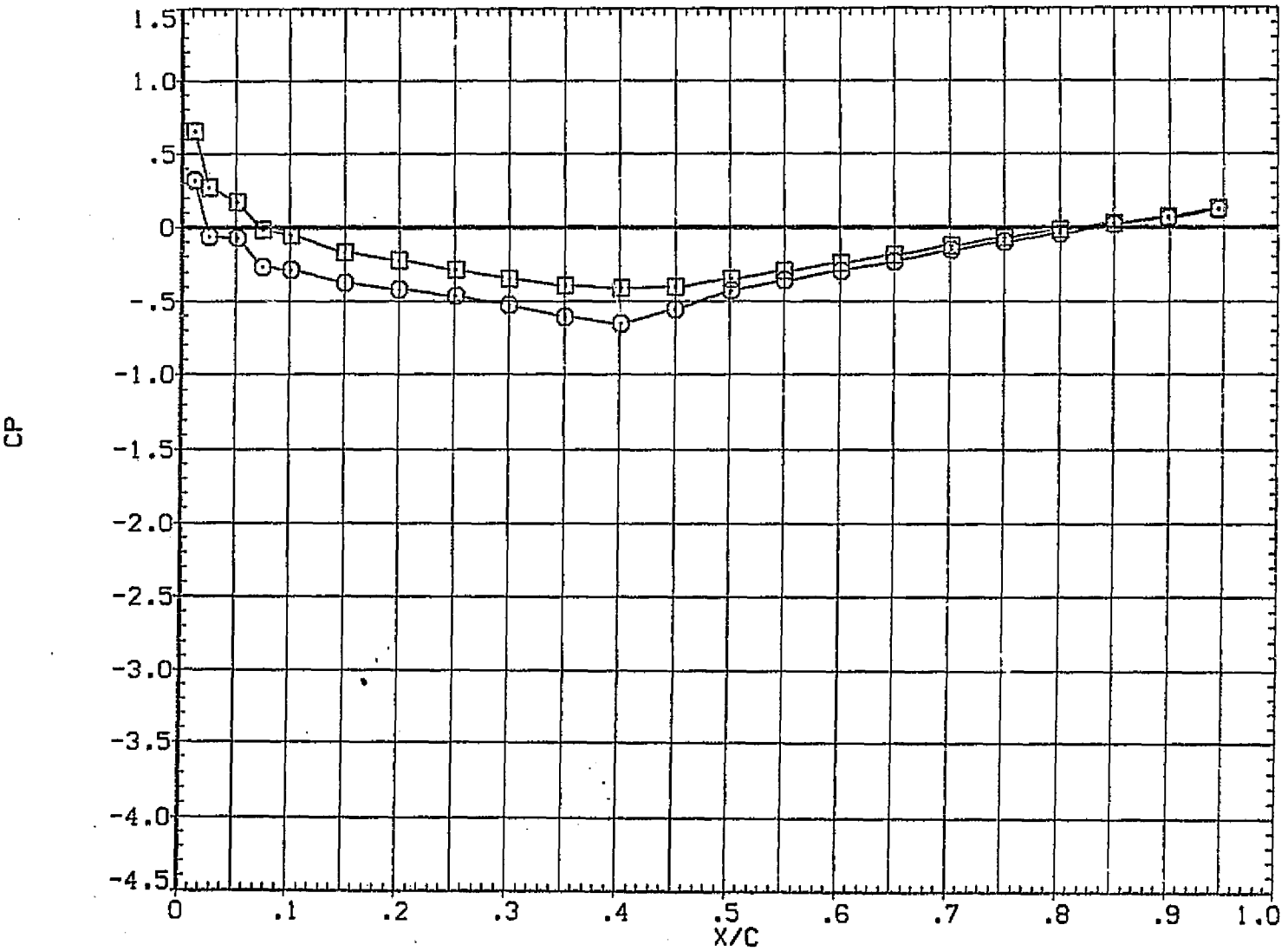

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

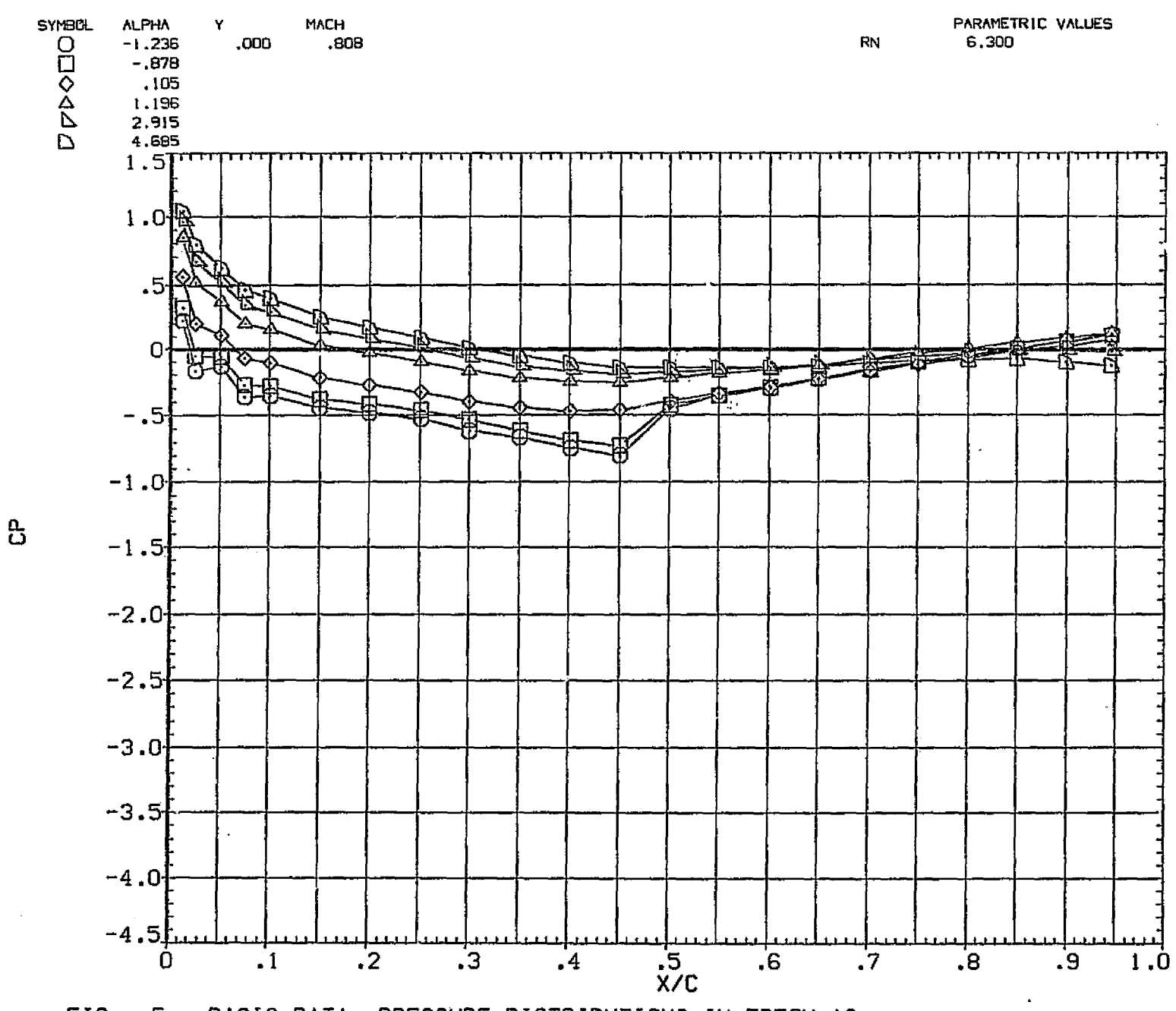

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

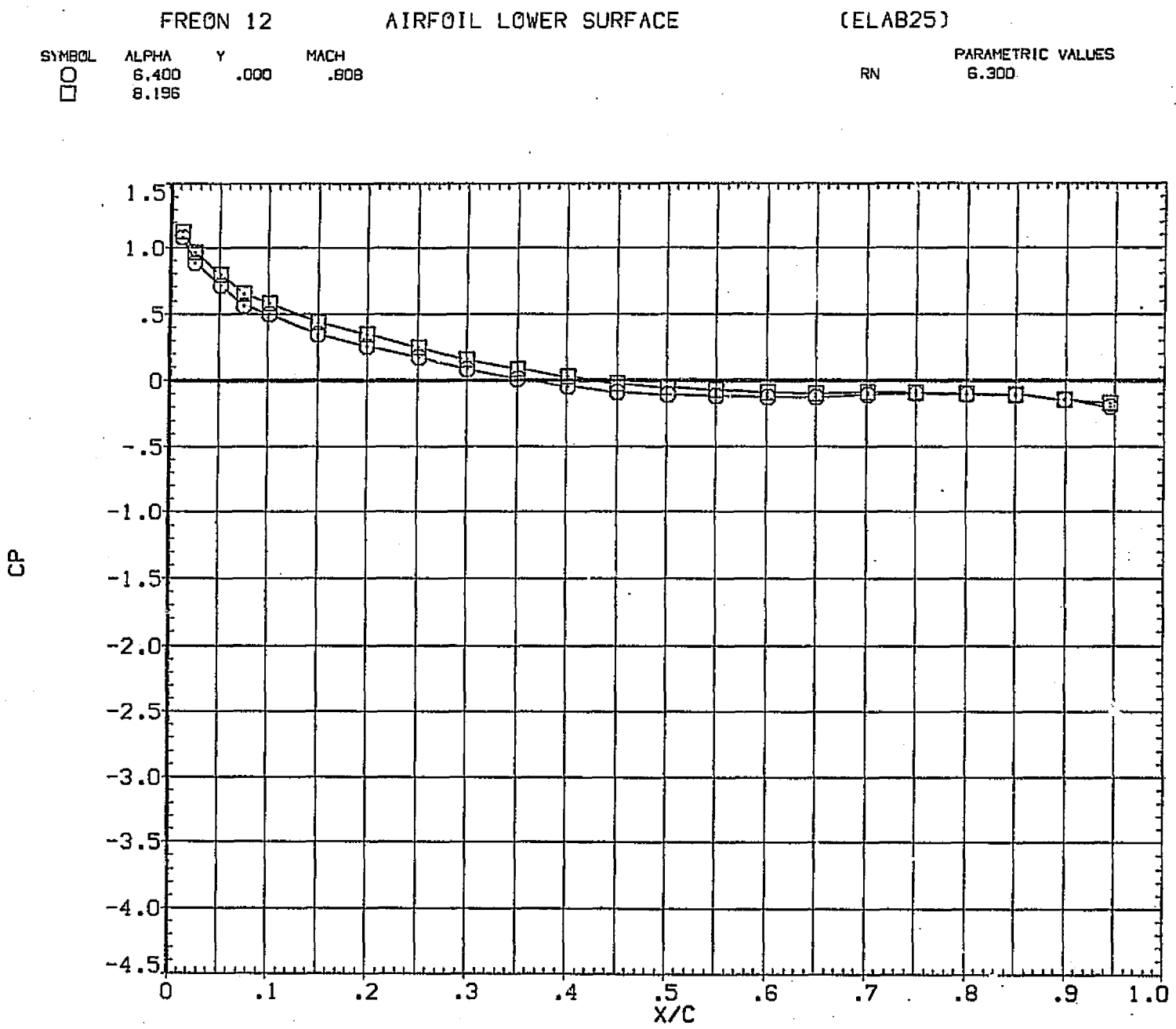

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

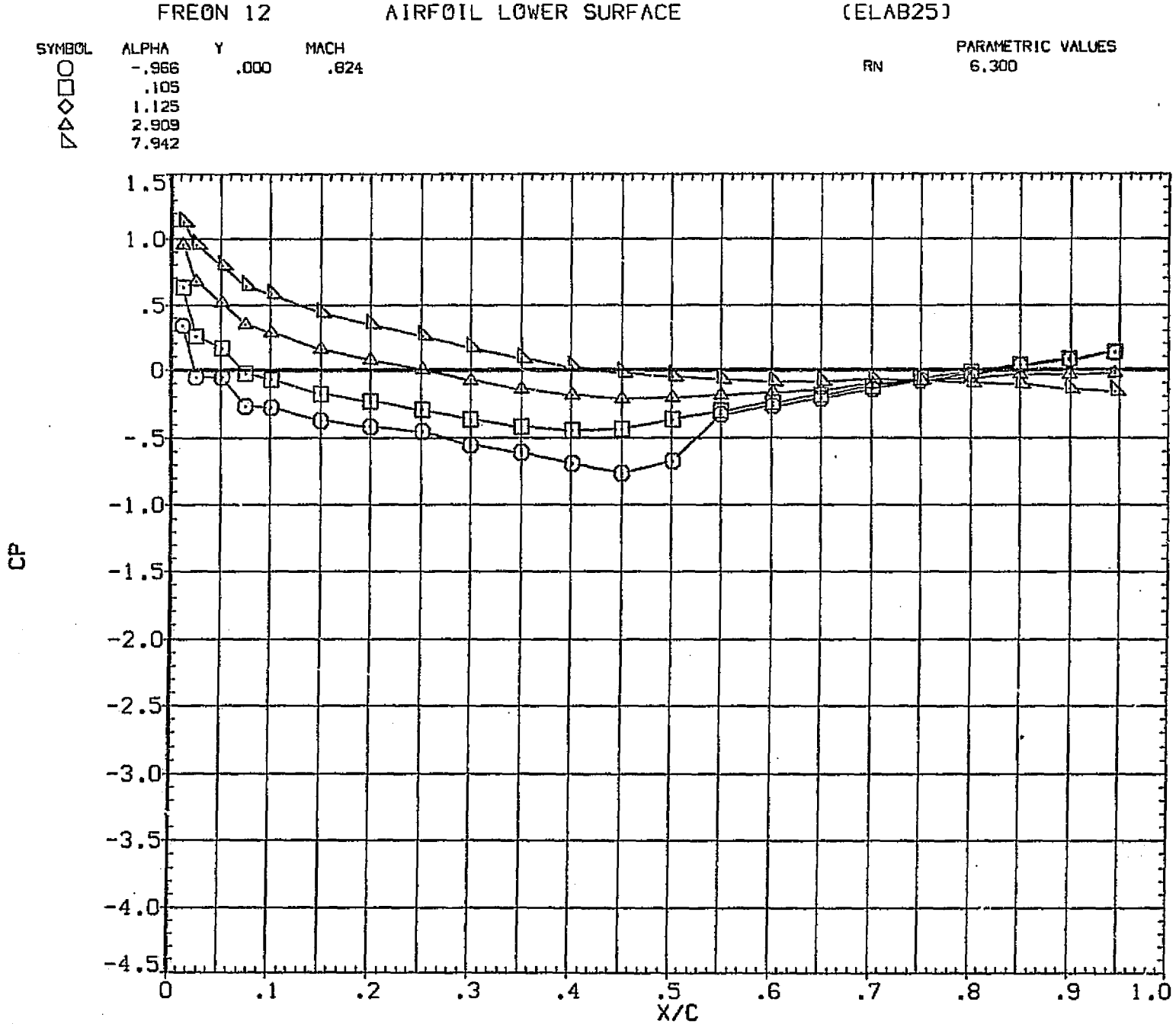

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

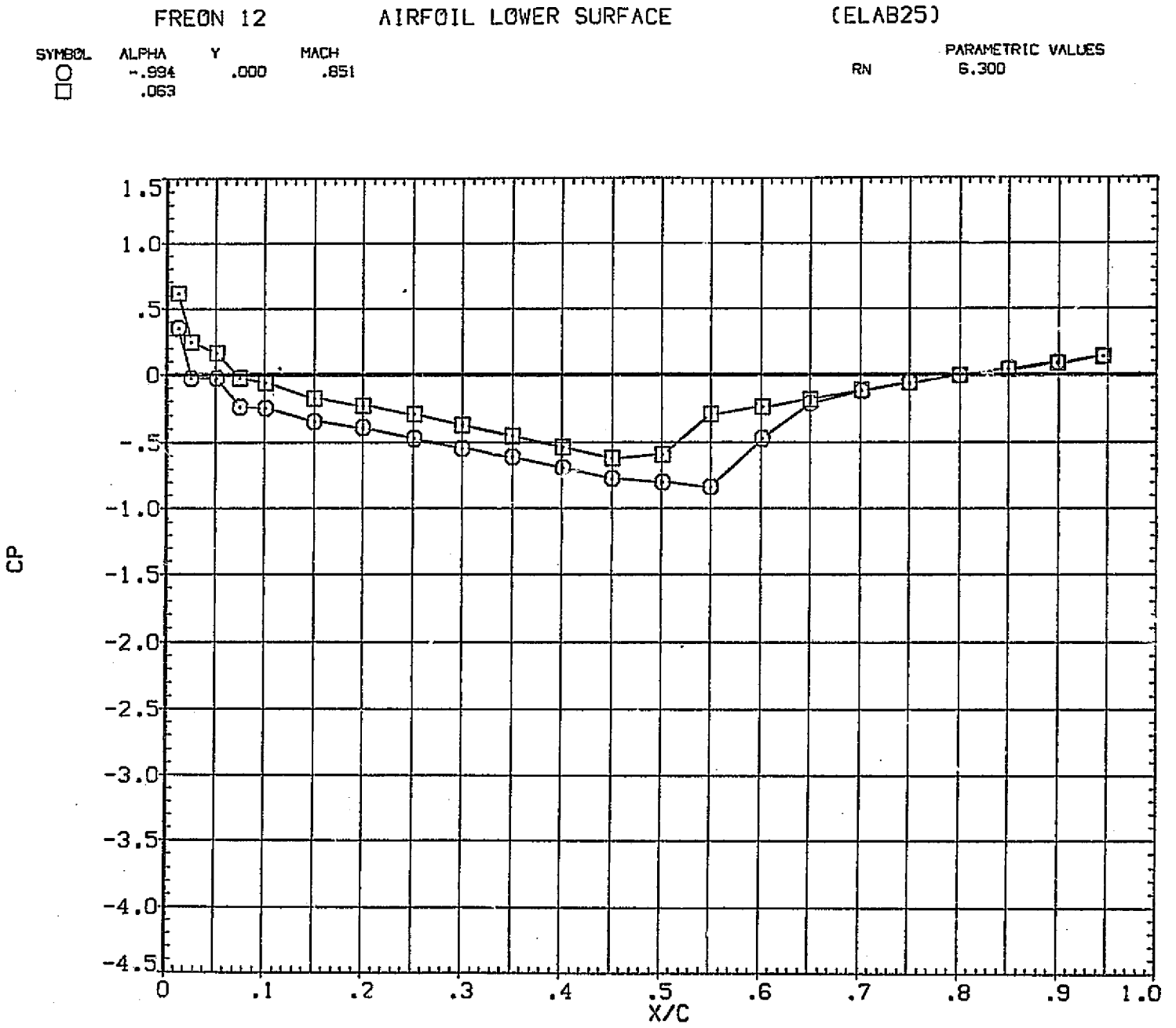

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

SYMBOL	ALPHA	Y	MACH
○	-1.103	.000	.895
□	.844		

PARAMETRIC VALUES
RN 6.300

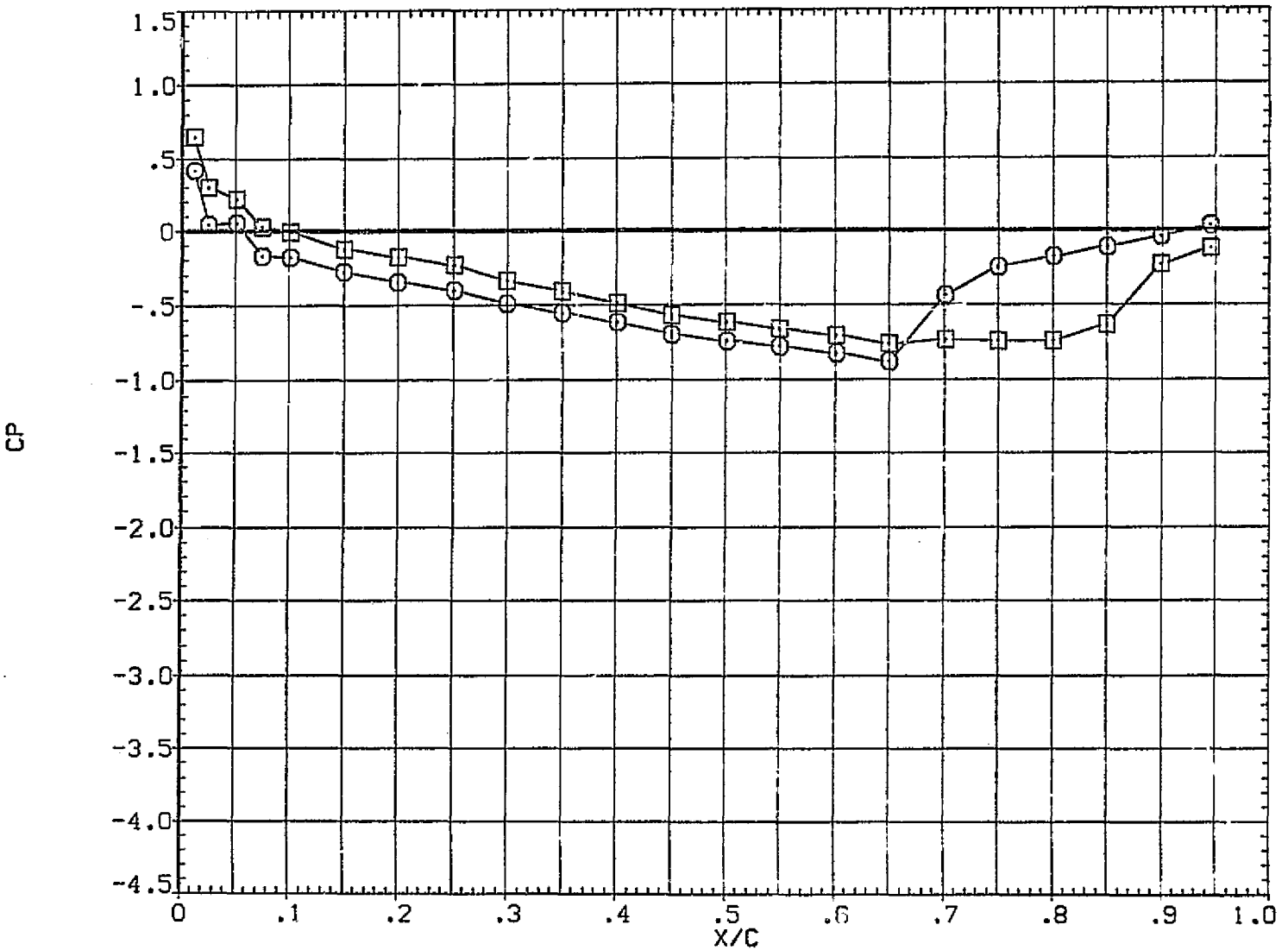

FIG. 5 BASIC DATA, PRESSURE DISTRIBUTIONS IN FREON 12

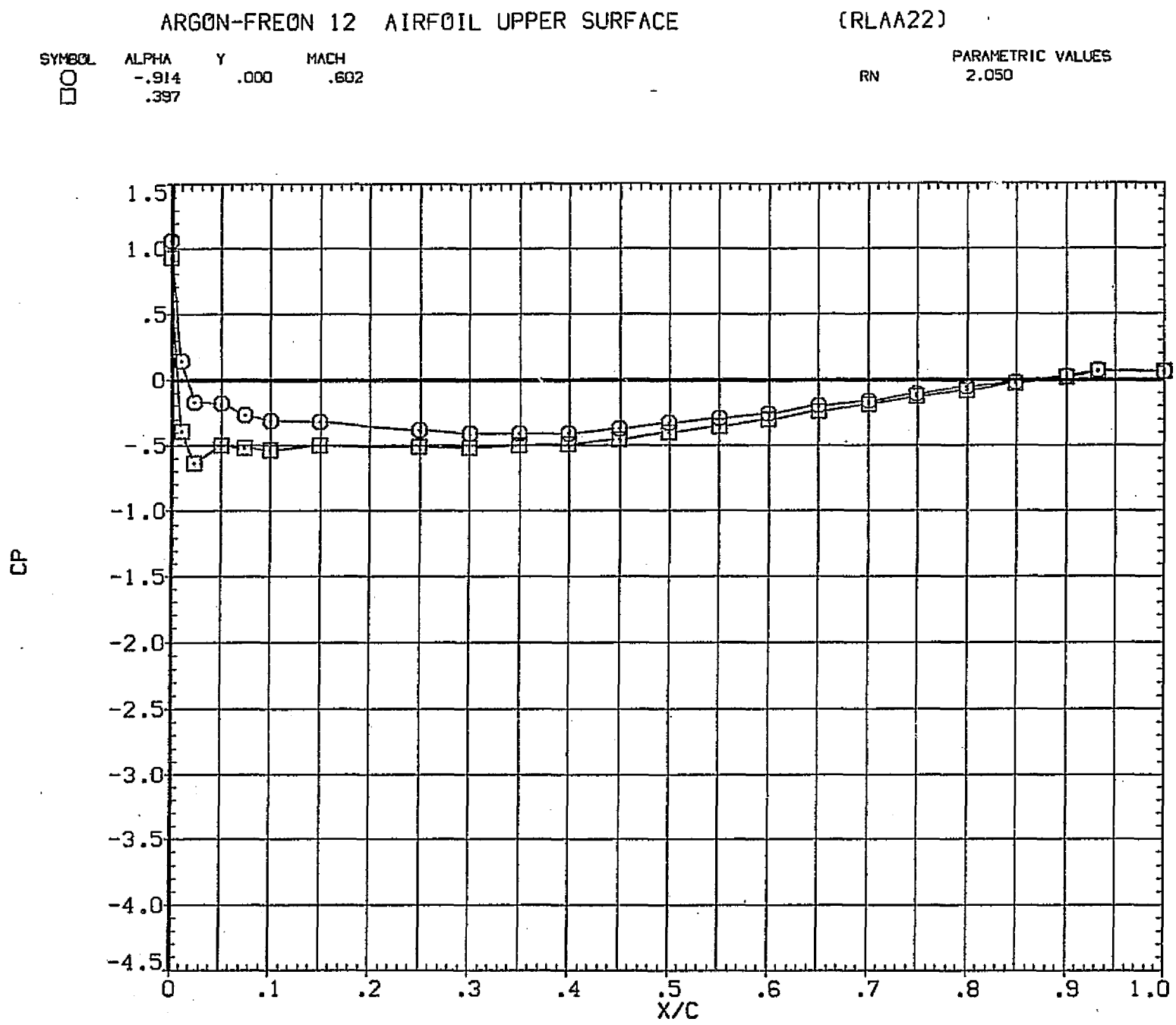

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

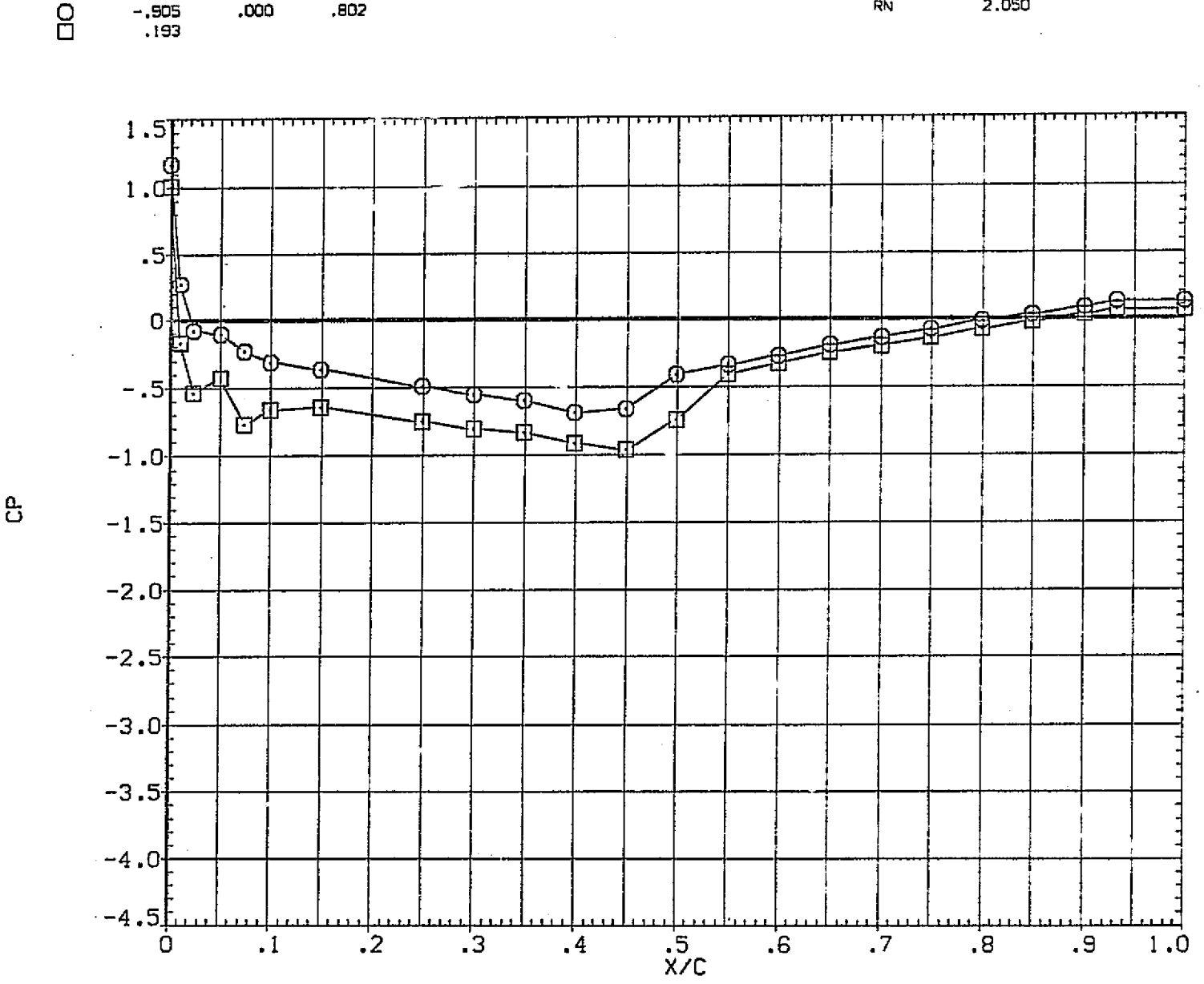

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIØNS IN ARGØN-FREØN 12

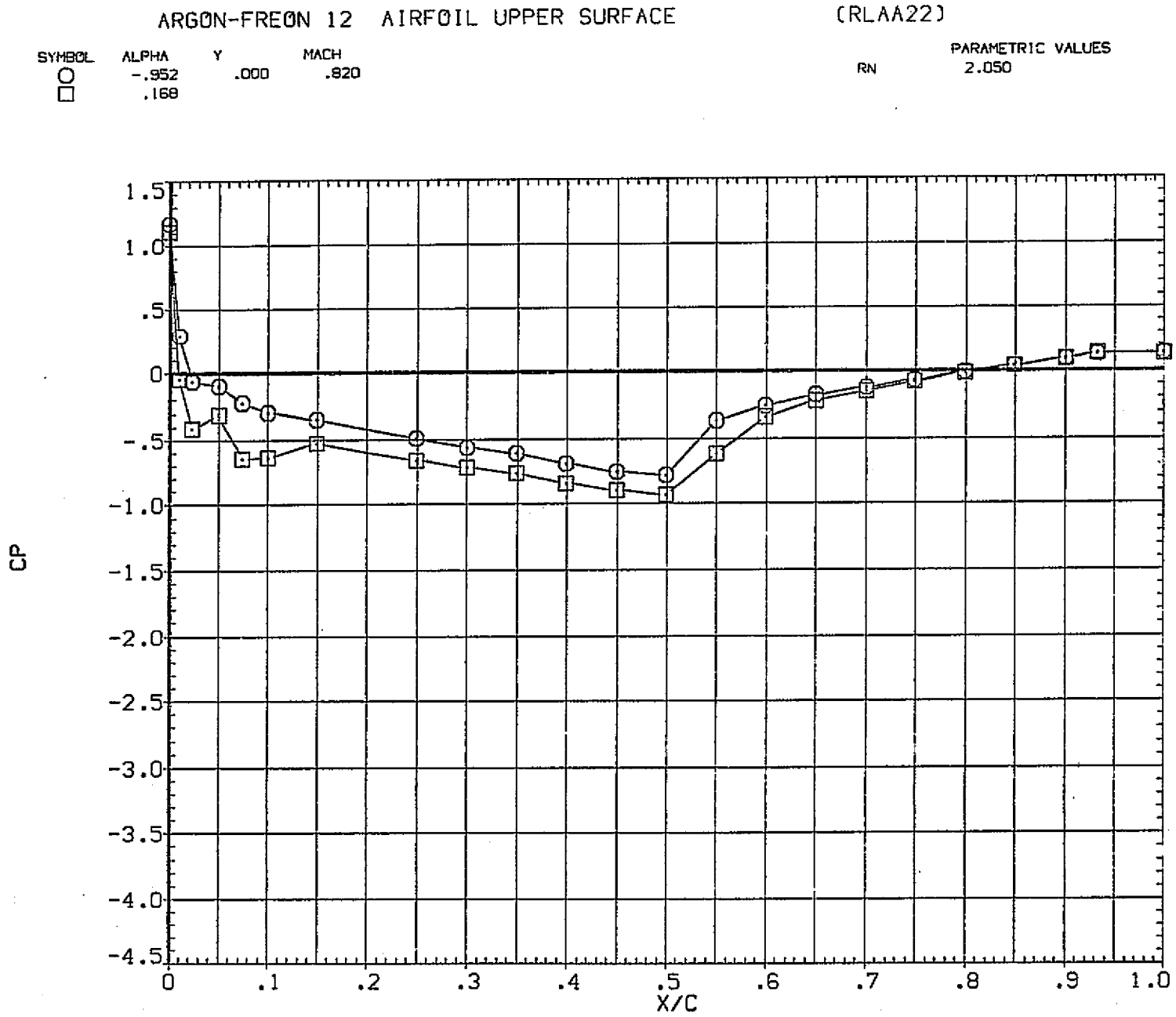

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

ARGON-FREON 12 AIRFOIL UPPER SURFACE (RLAA22)

SYMBOL	ALPHA	Y	MACH
○	-.969	.000	.852
□	.326		

PARAMETRIC VALUES

RN 2.050

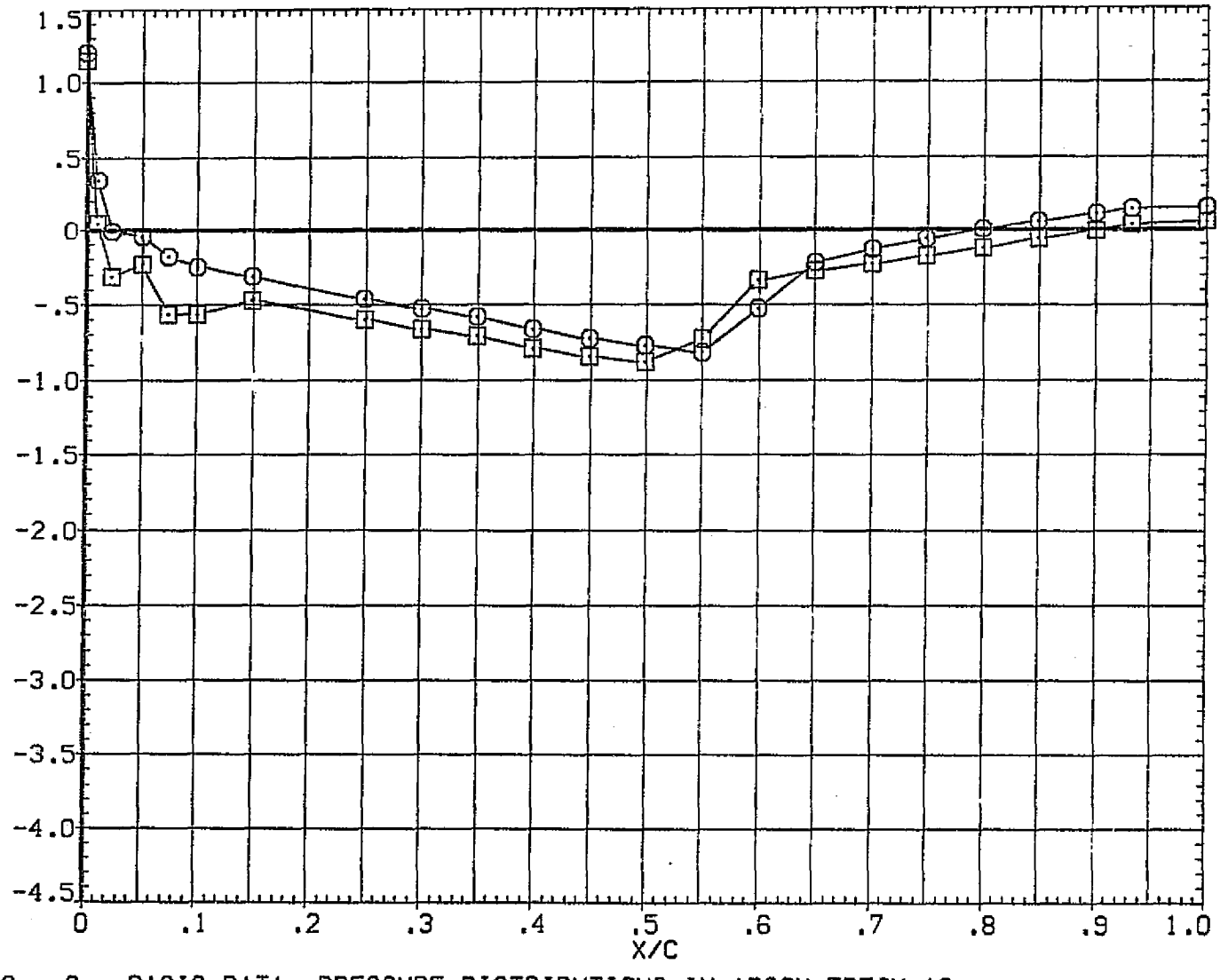

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

ARGON-FREON 12 AIRFOIL UPPER SURFACE (RLAA23)

SYMBOL	ALPHA	Y	MACH
○	-.827	.000	.602
□	.416		

PARAMETRIC VALUES

RN 3.050

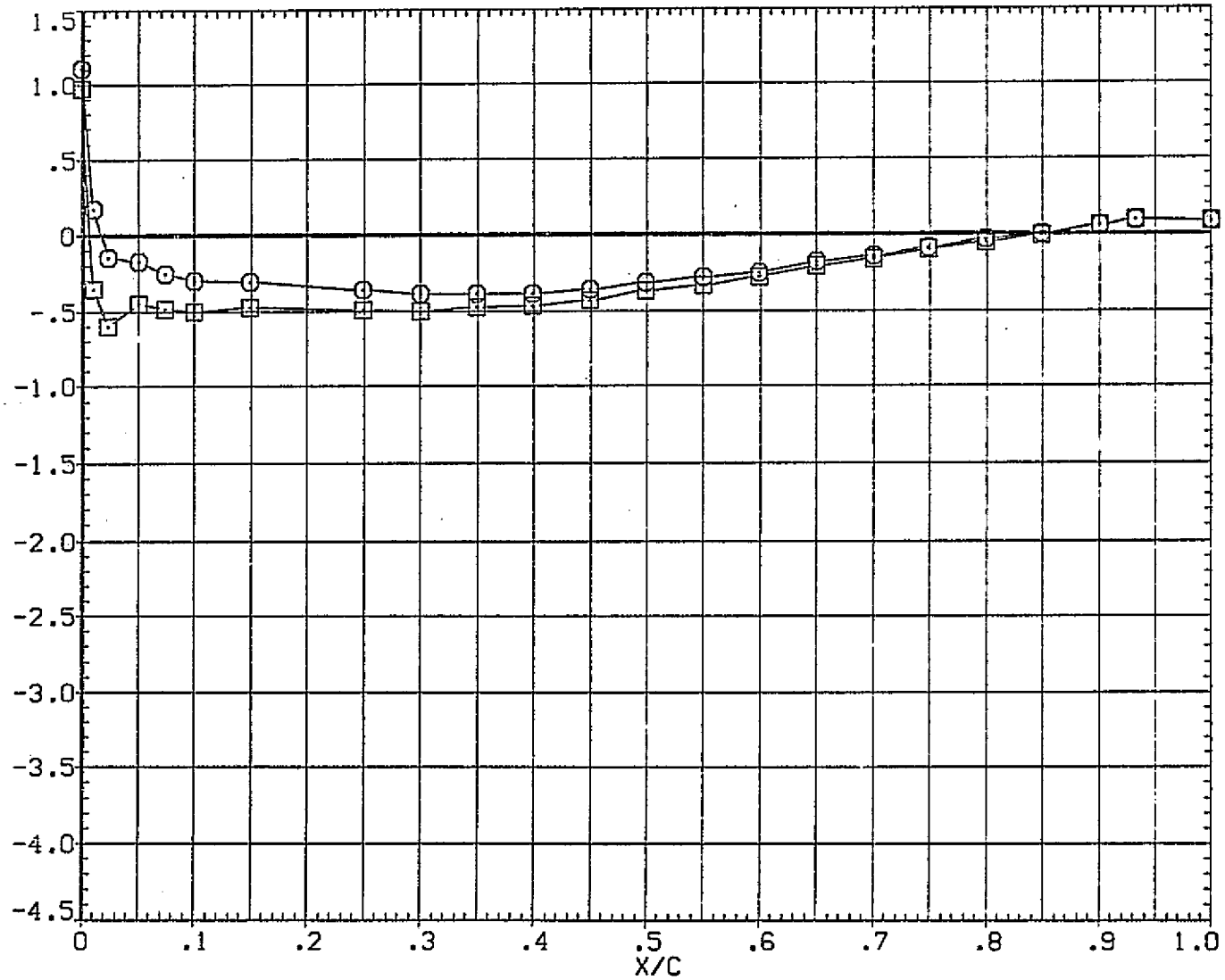

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

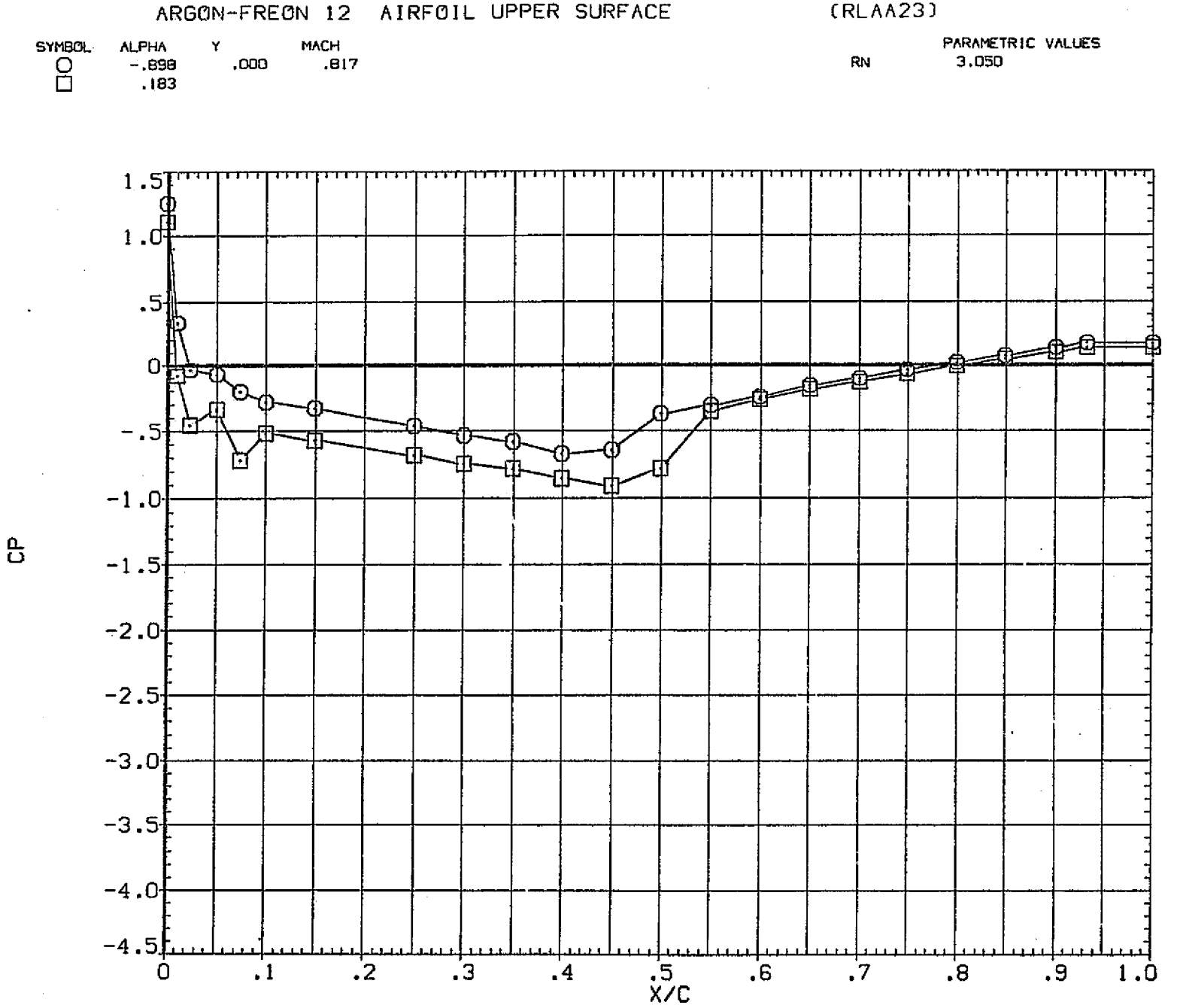

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

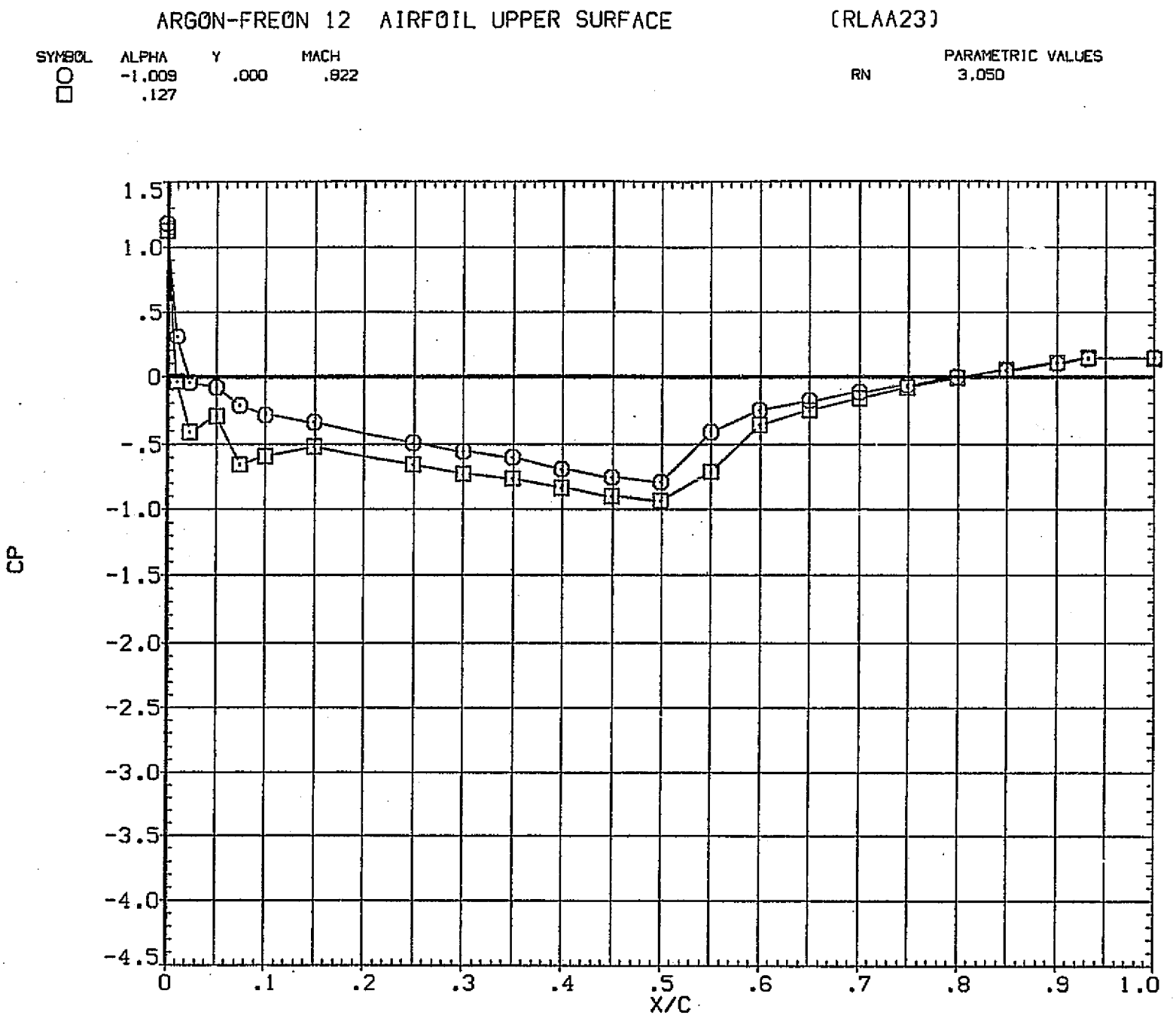

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

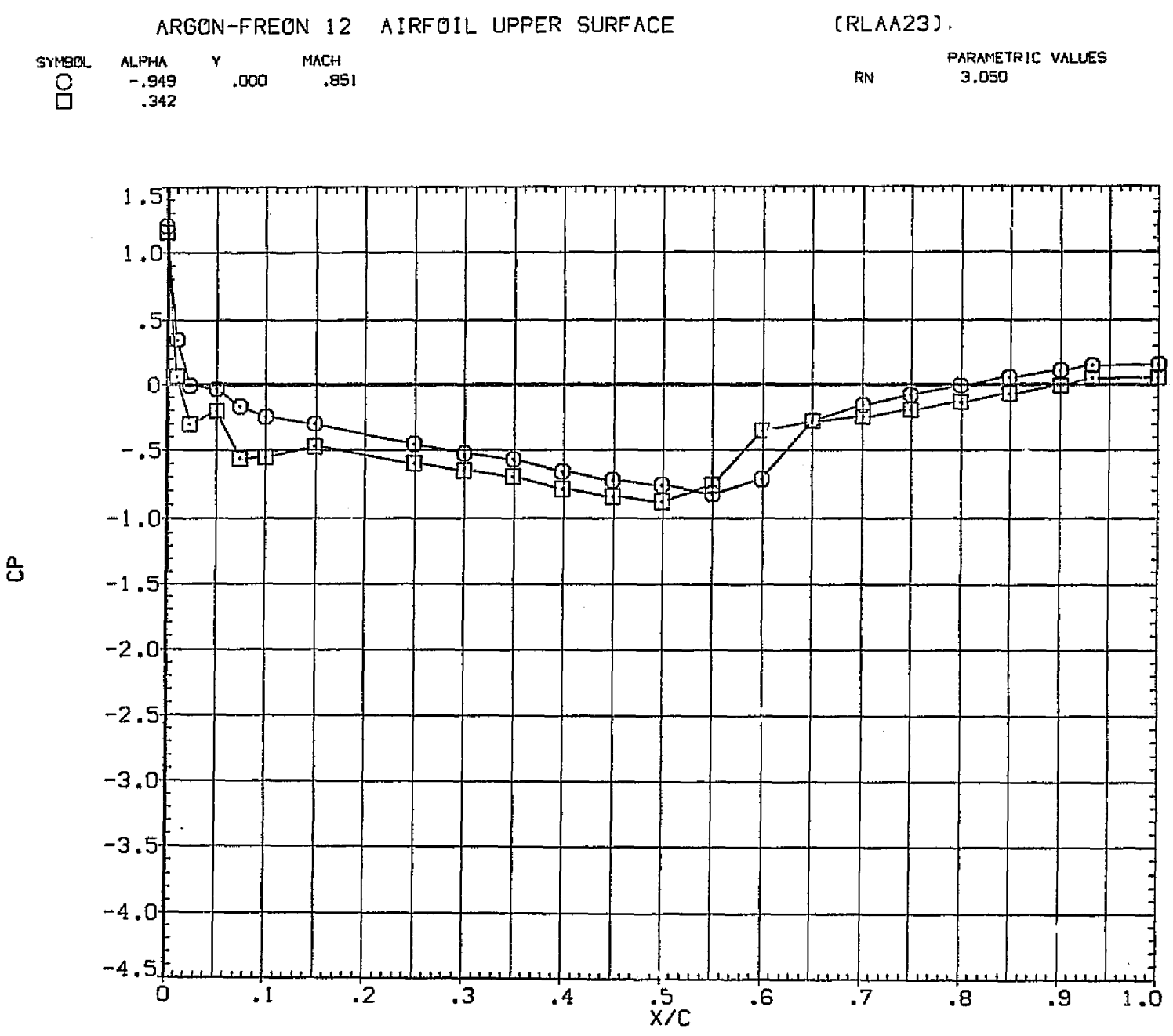

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

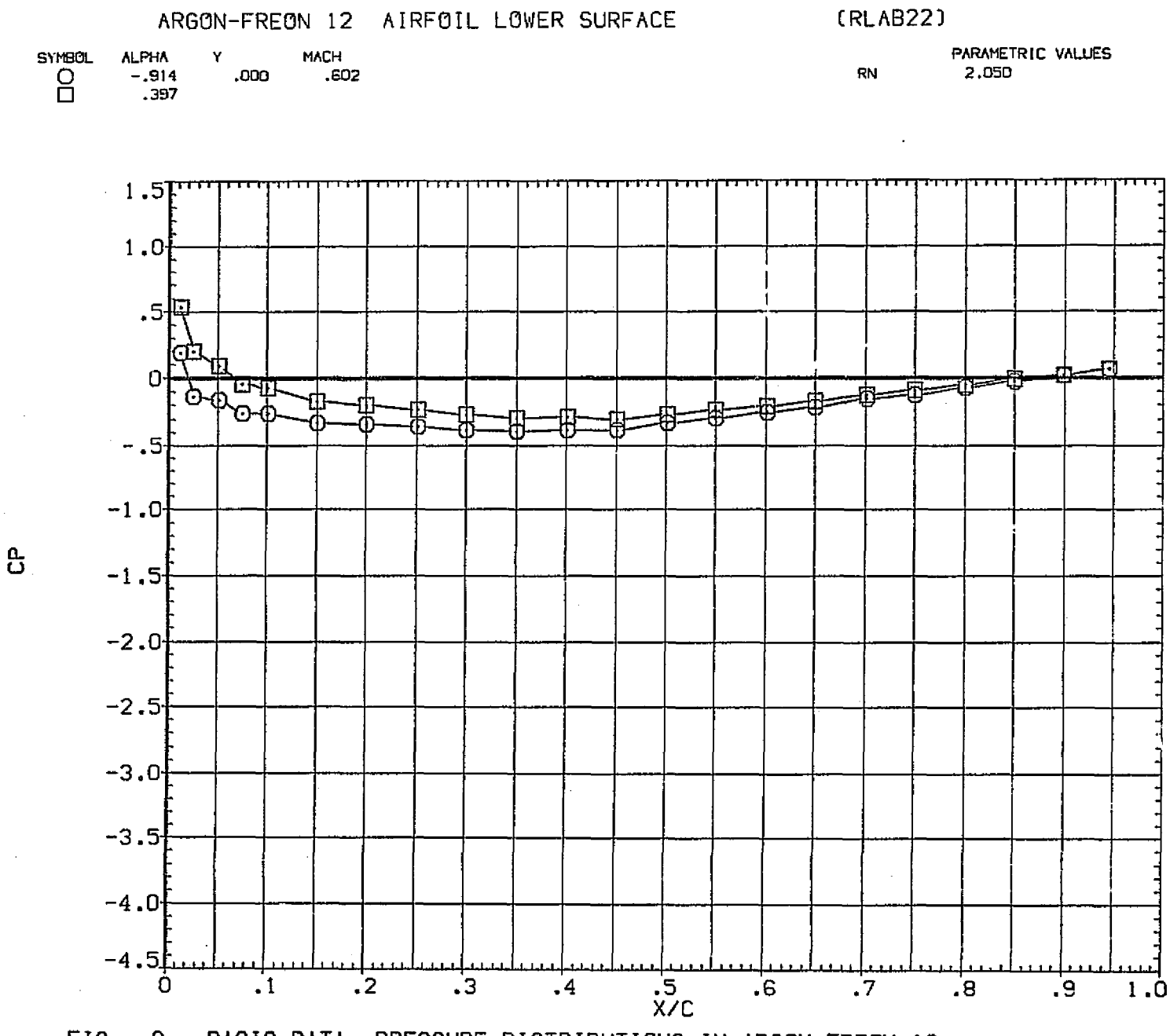

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

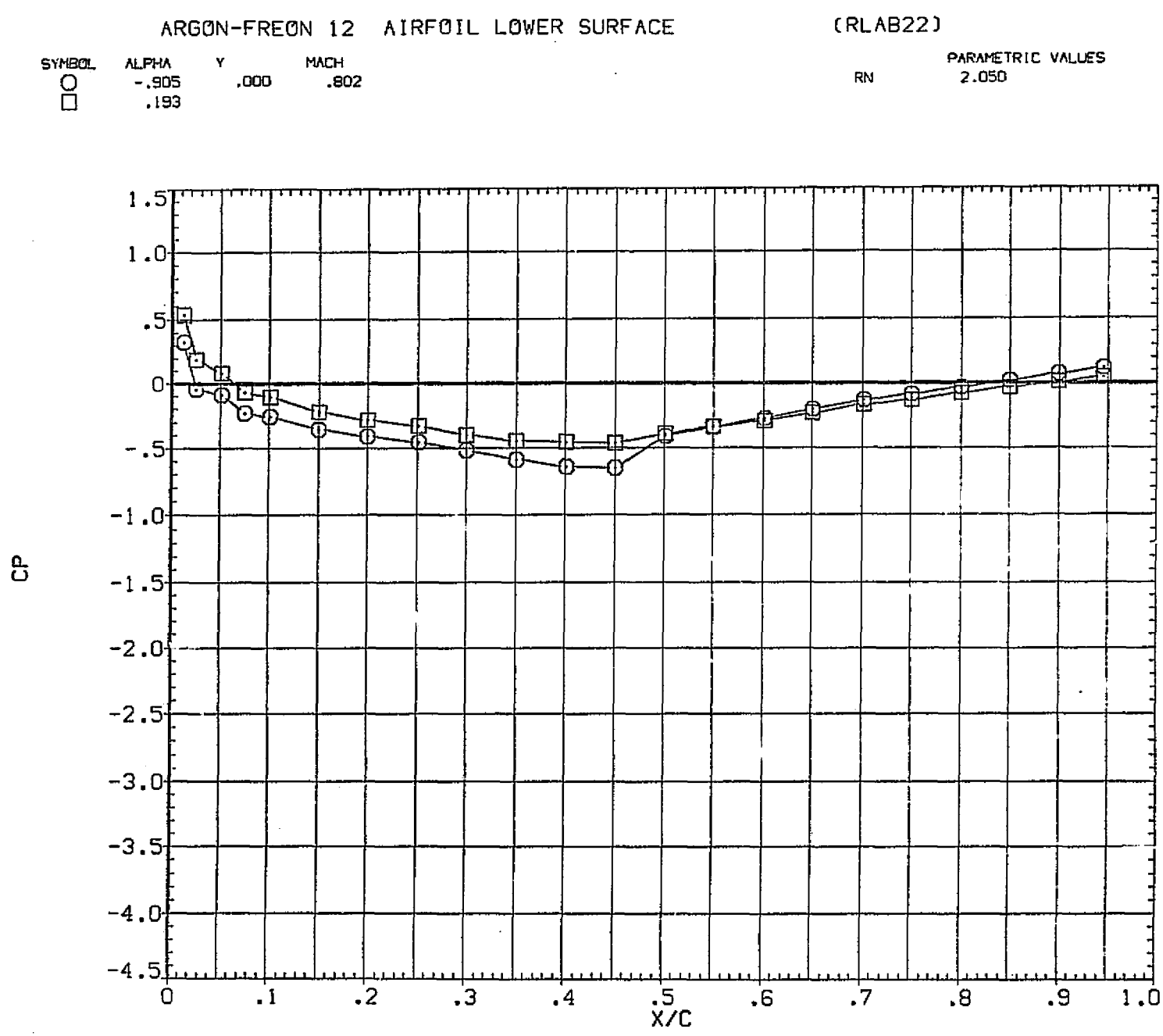

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

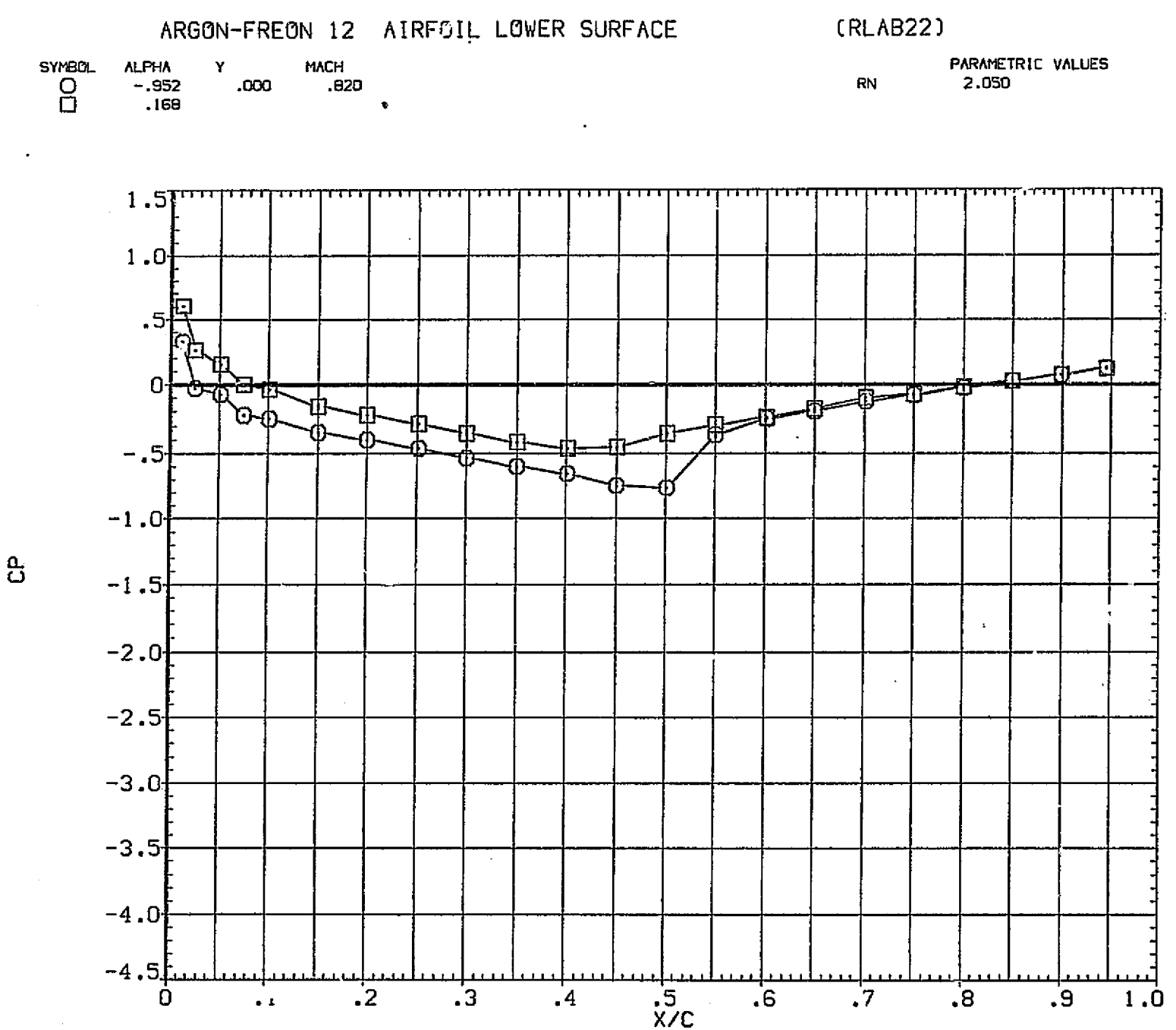

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

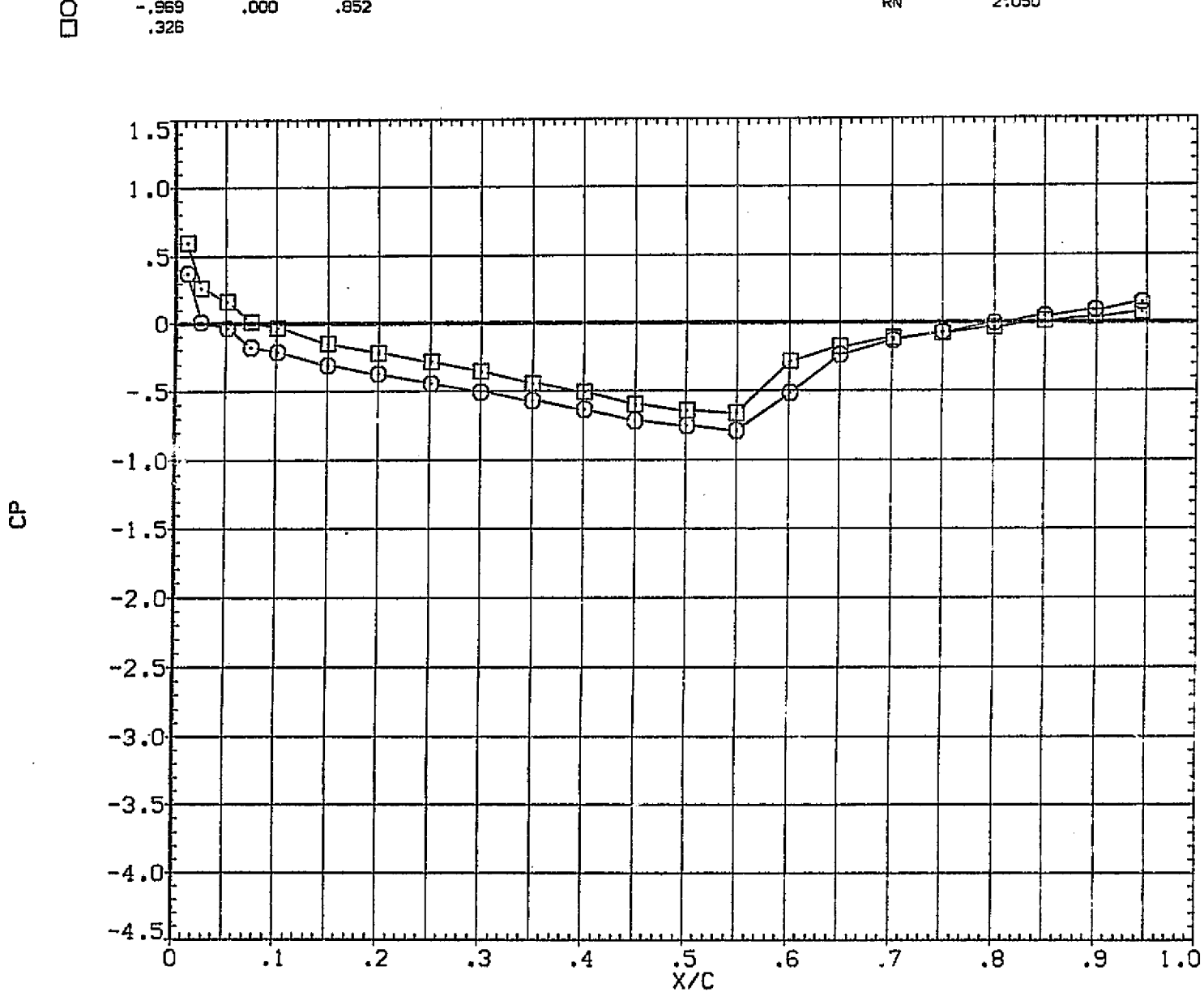

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

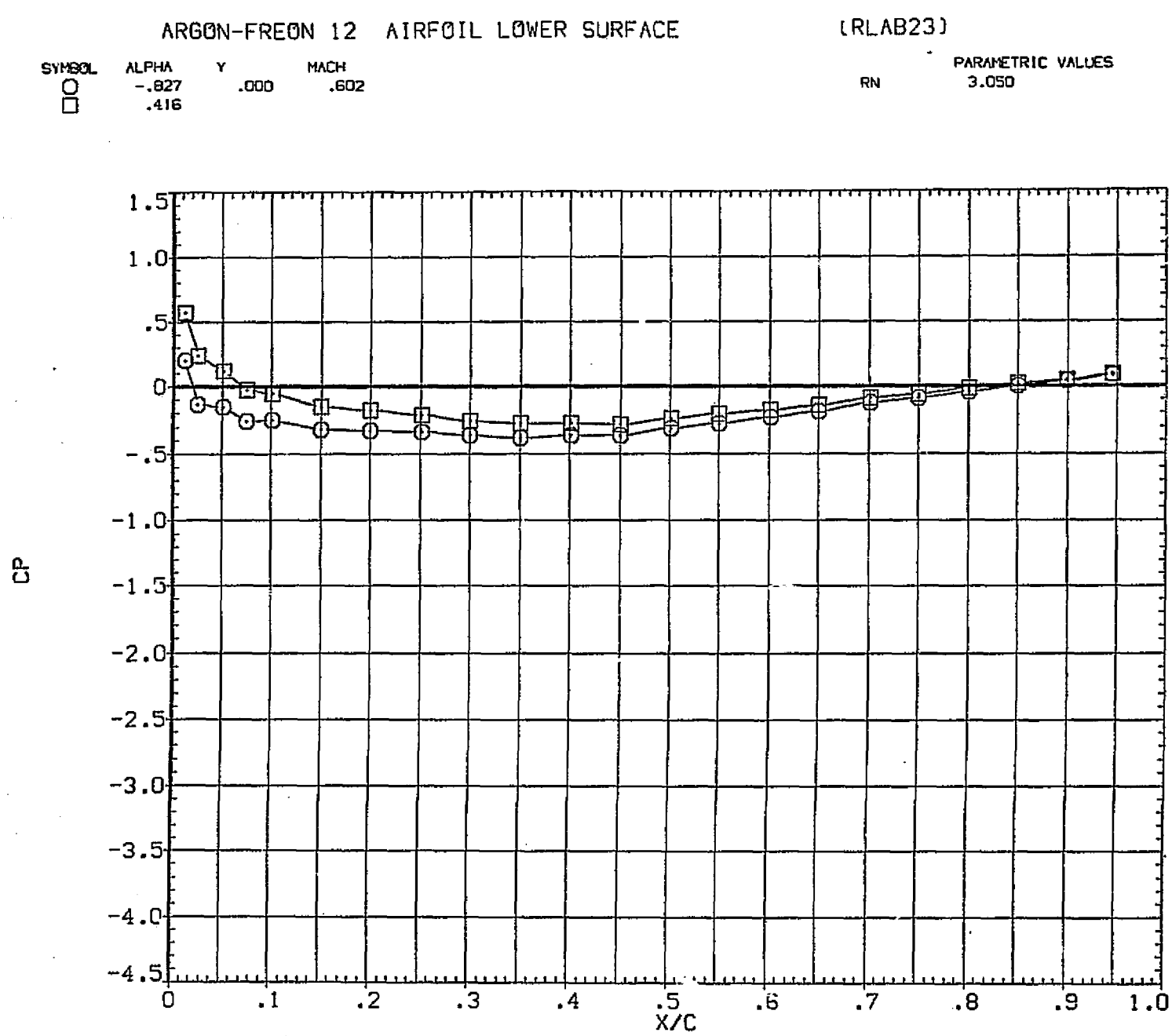

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

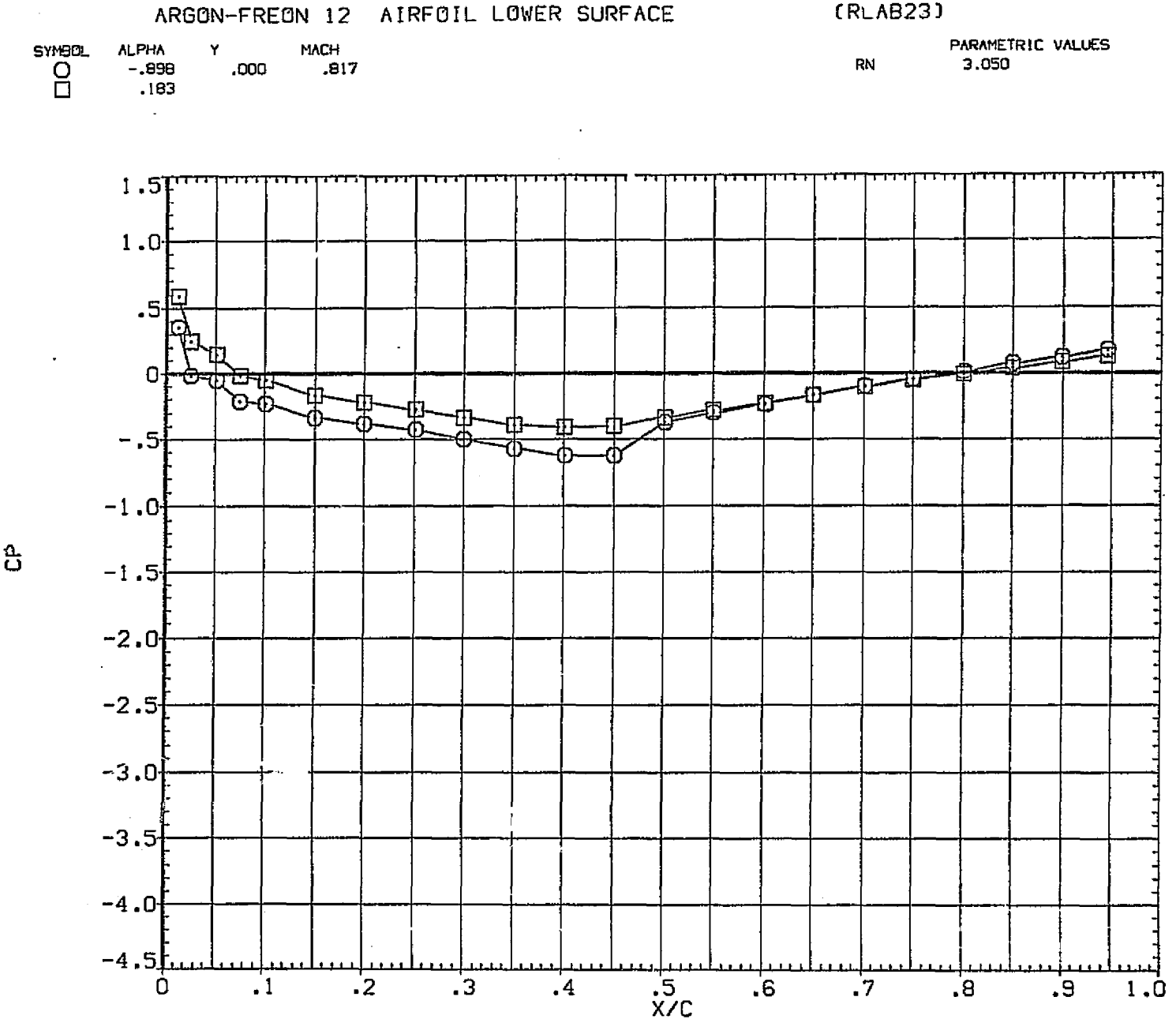

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

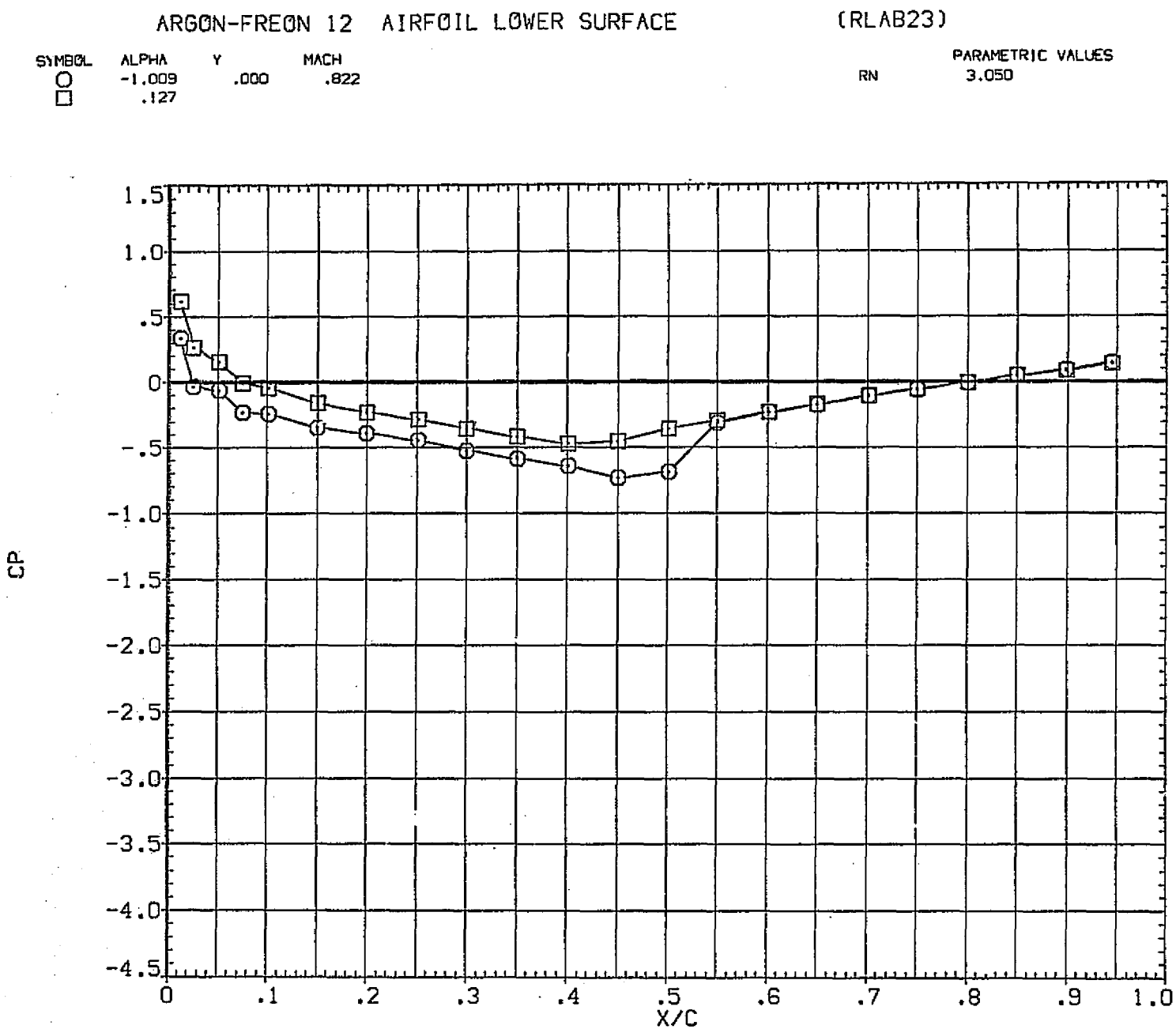

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

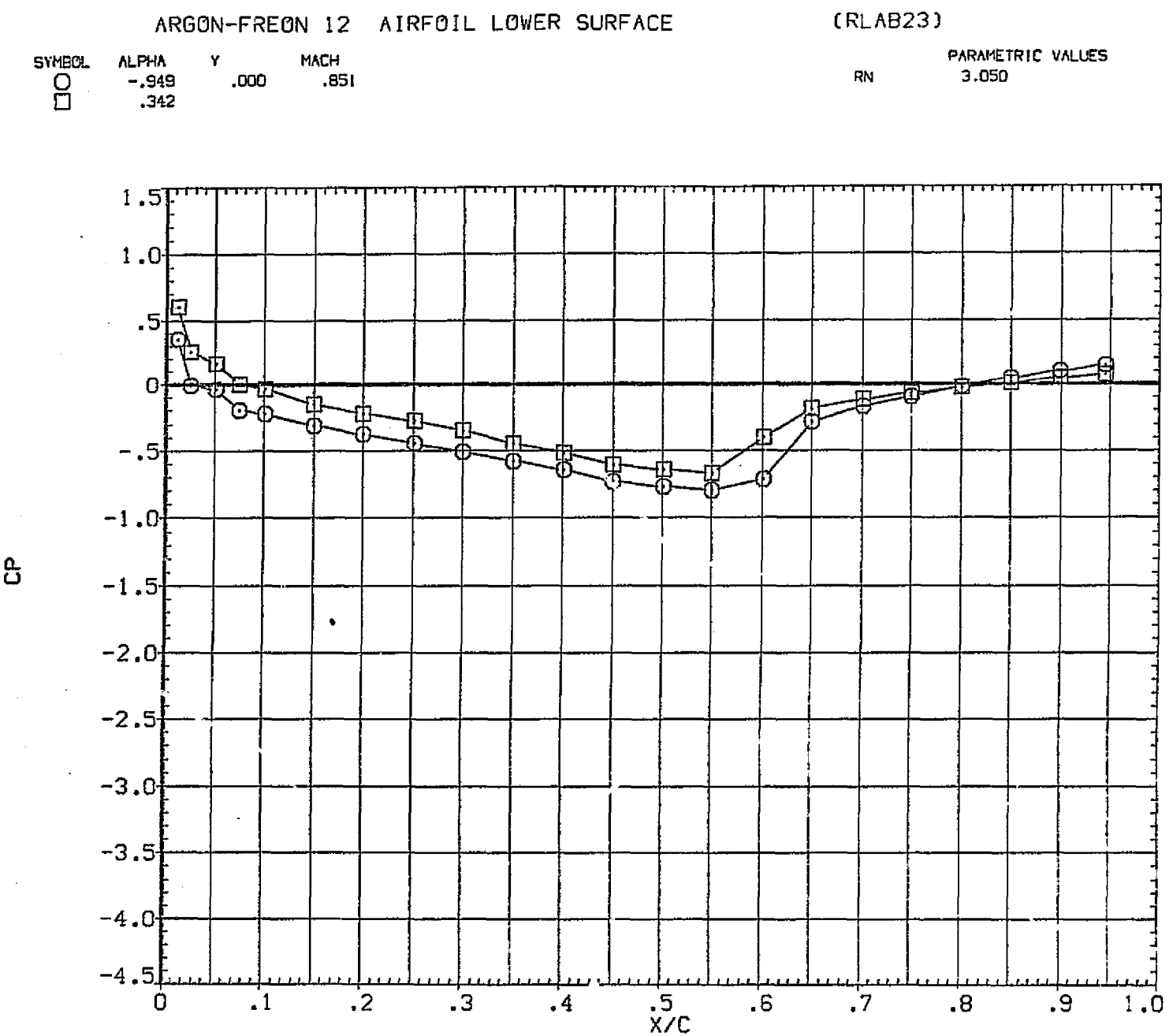

FIG. 6 BASIC DATA, PRESSURE DISTRIBUTIONS IN ARGON-FREON 12

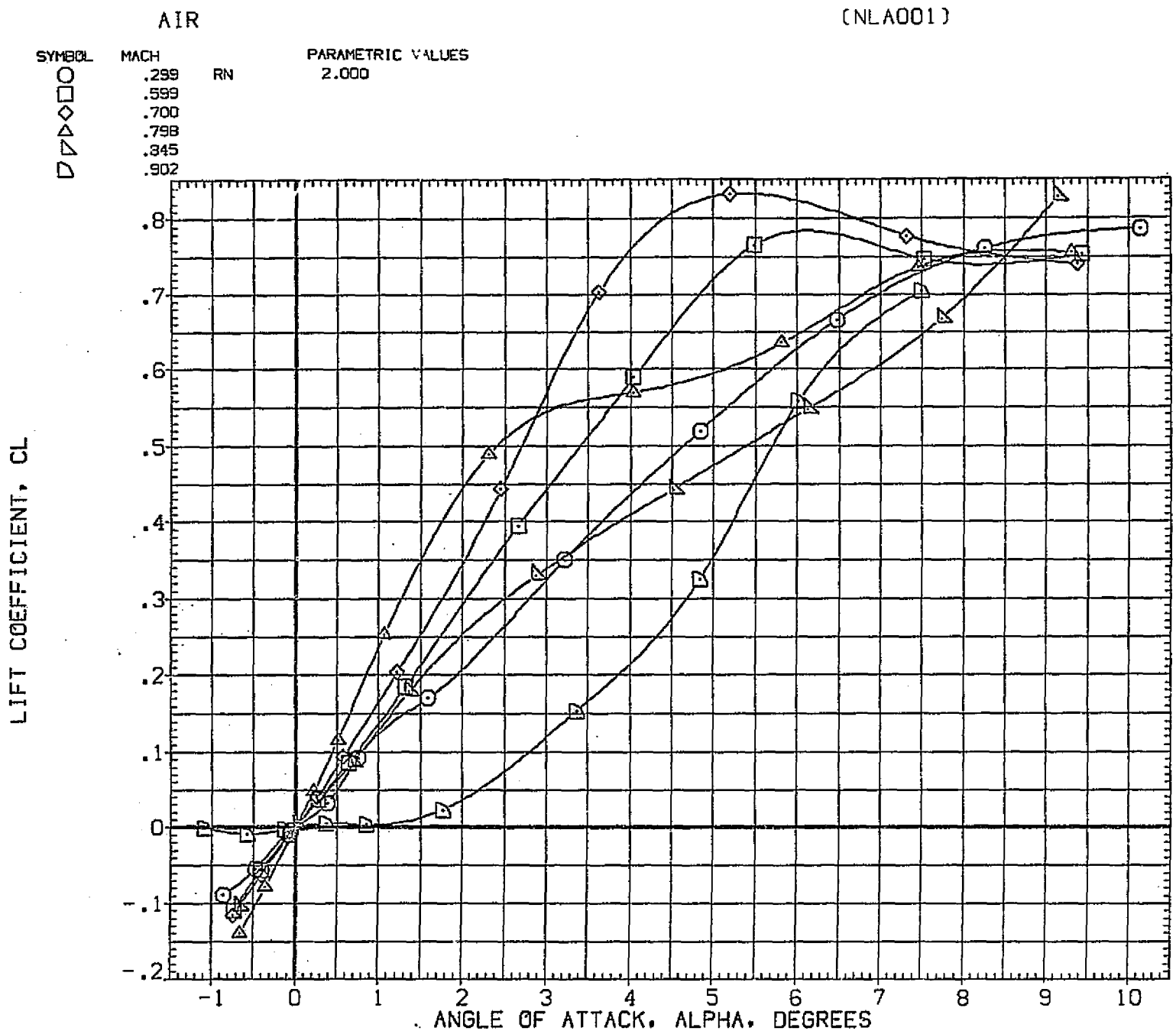

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

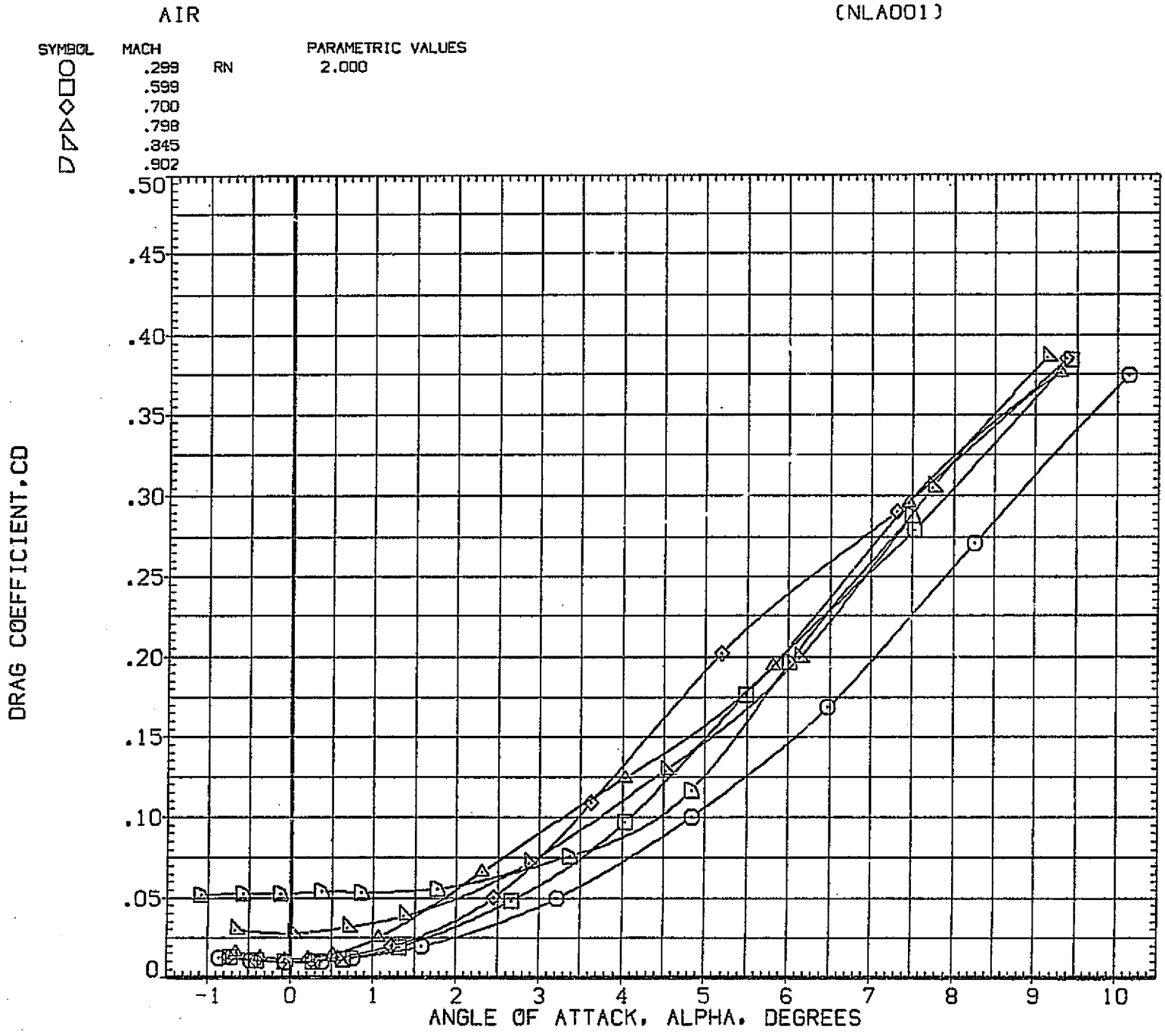

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

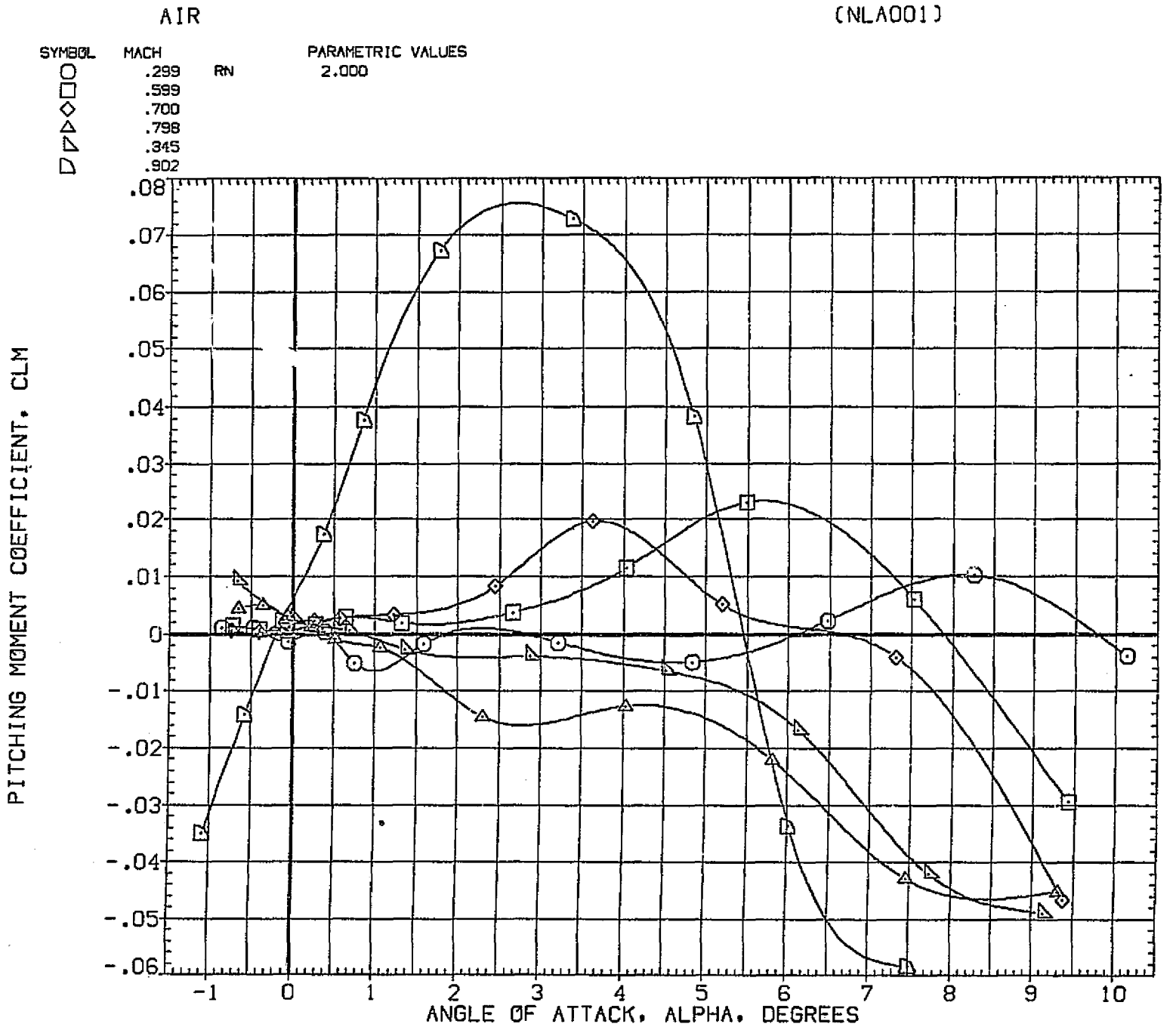

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

SYMBOL	MACH		PARAMETRIC VALUES
○	.600	RN	2.500
□	.700		
◇	.798		

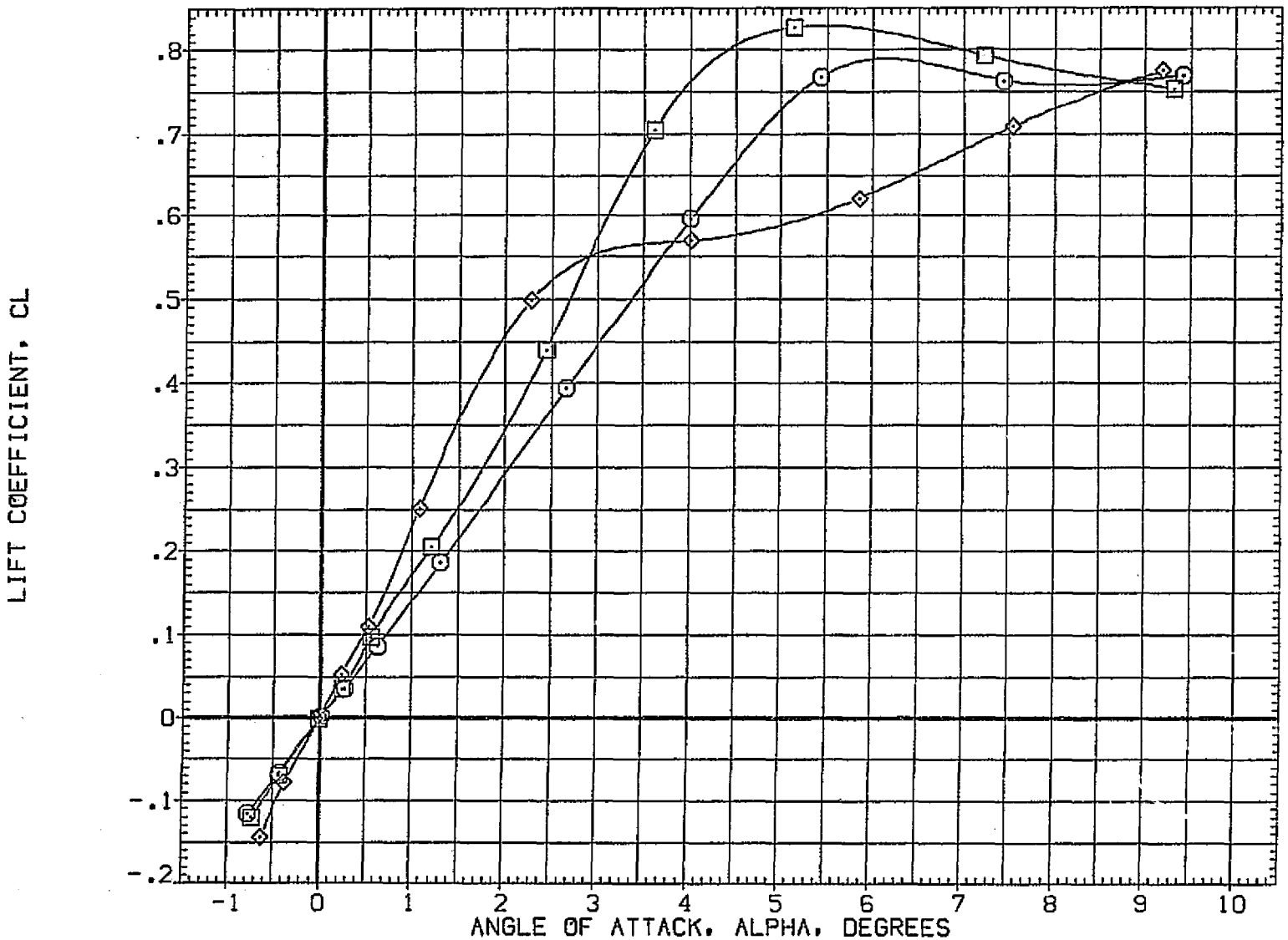

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

AIR (NLA002)

SYMBOL	MACH		PARAMETRIC VALUES
○	.600	RN	2.500
□	.700		
◇	.798		

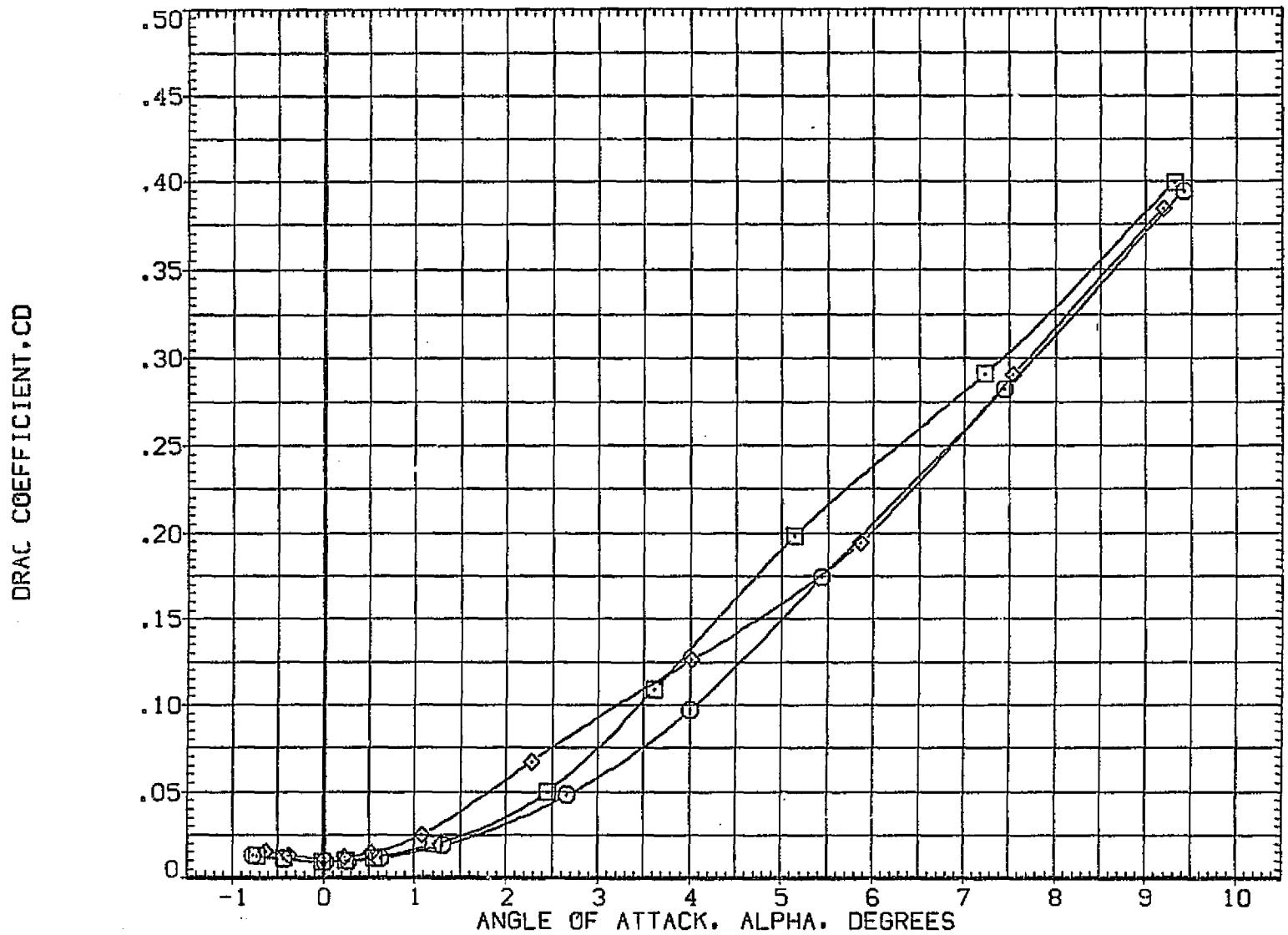

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

AIR (NLA002)

SYMBOL	MACH		PARAMETRIC VALUES
○	.600	RN	2.500
□	.700		
◇	.798		

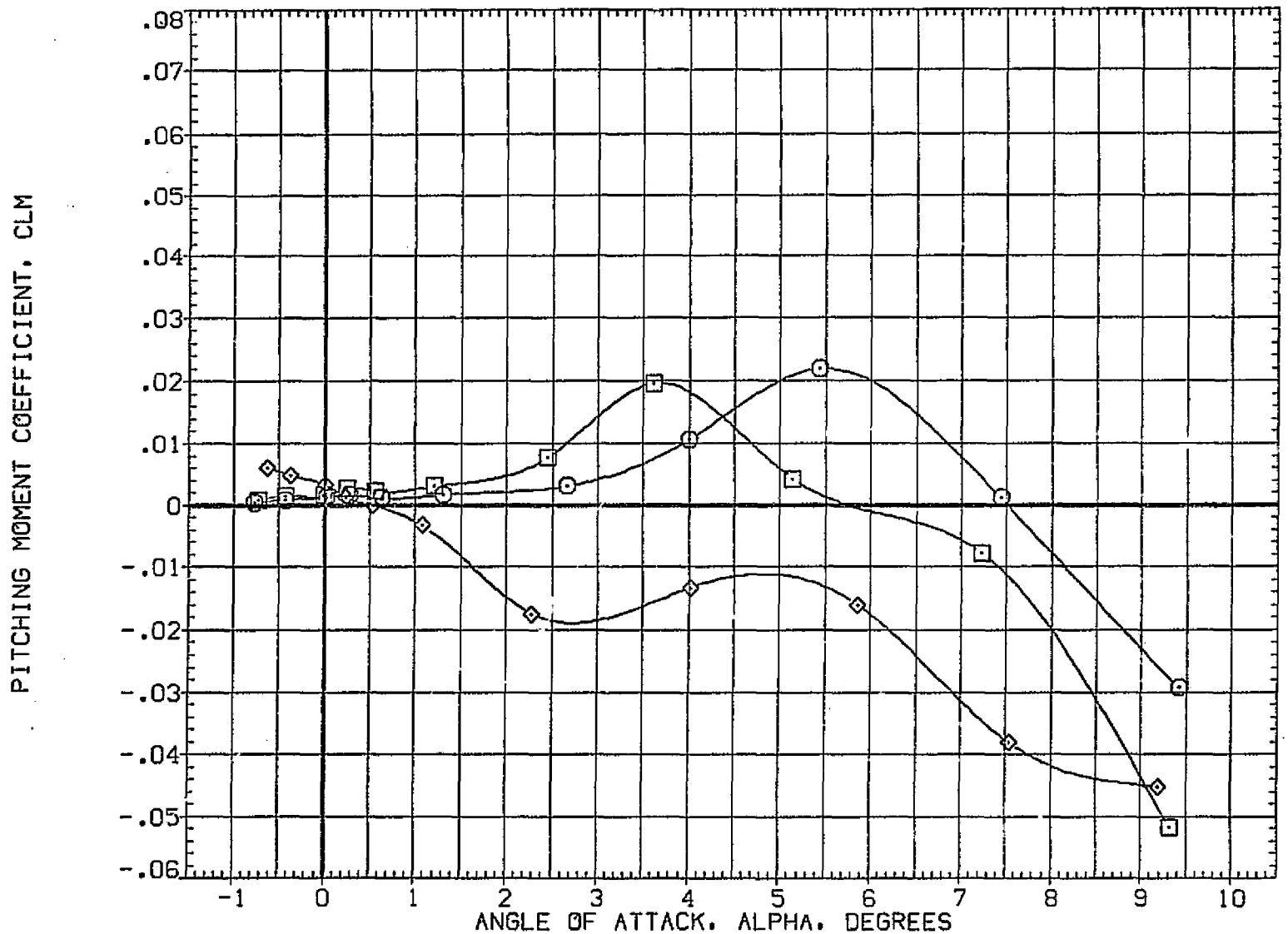

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

AIR (NLA003)

SYMBOL	MACH		PARAMETRIC VALUES
○	.399	RN	3.000
□	.602		
◇	.699		
△	.805		

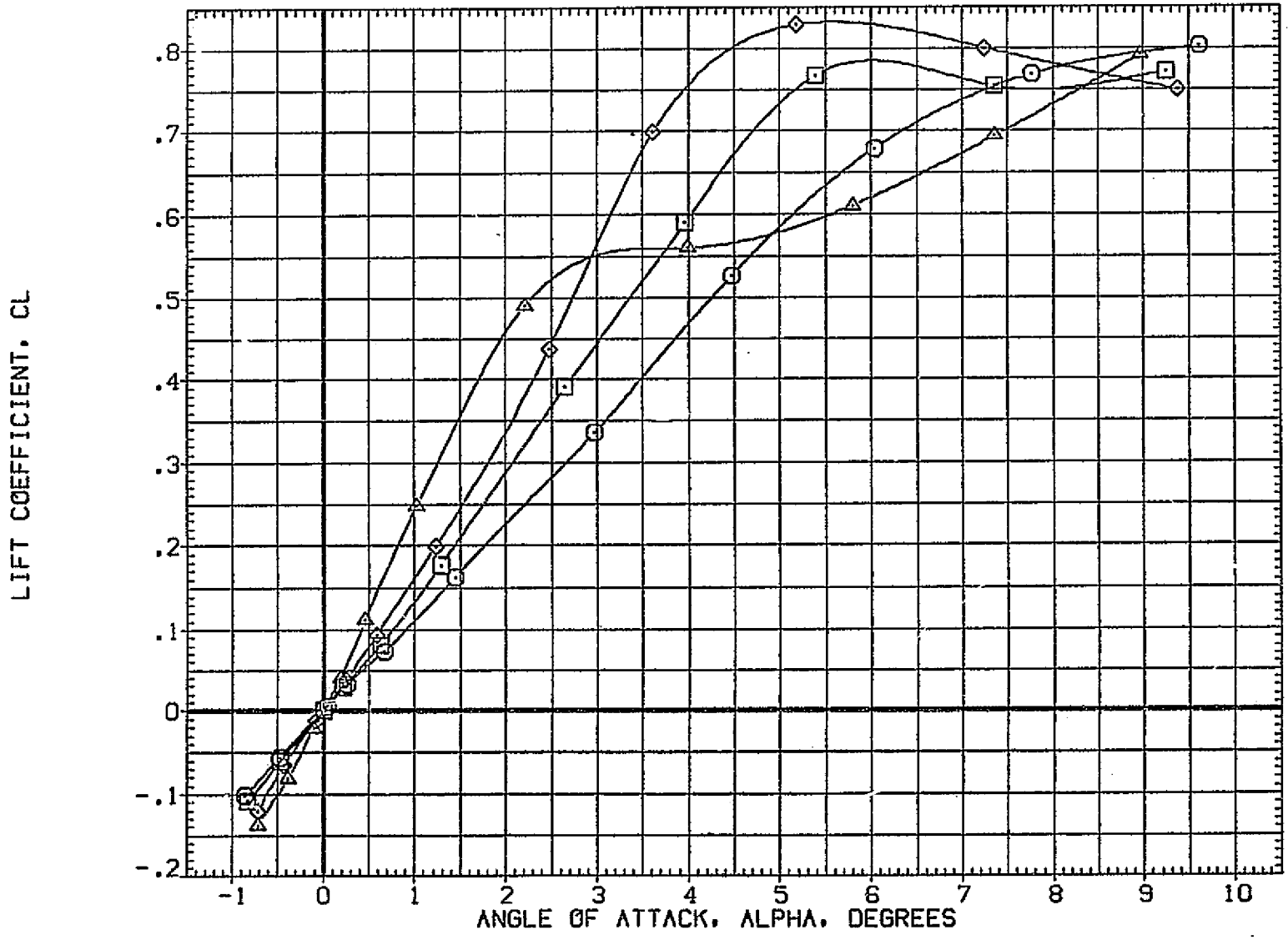

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

SYMBOL	MACH		PARAMETRIC VALUES
○	.823	RN	3.000
□	.832		
◇	.902		

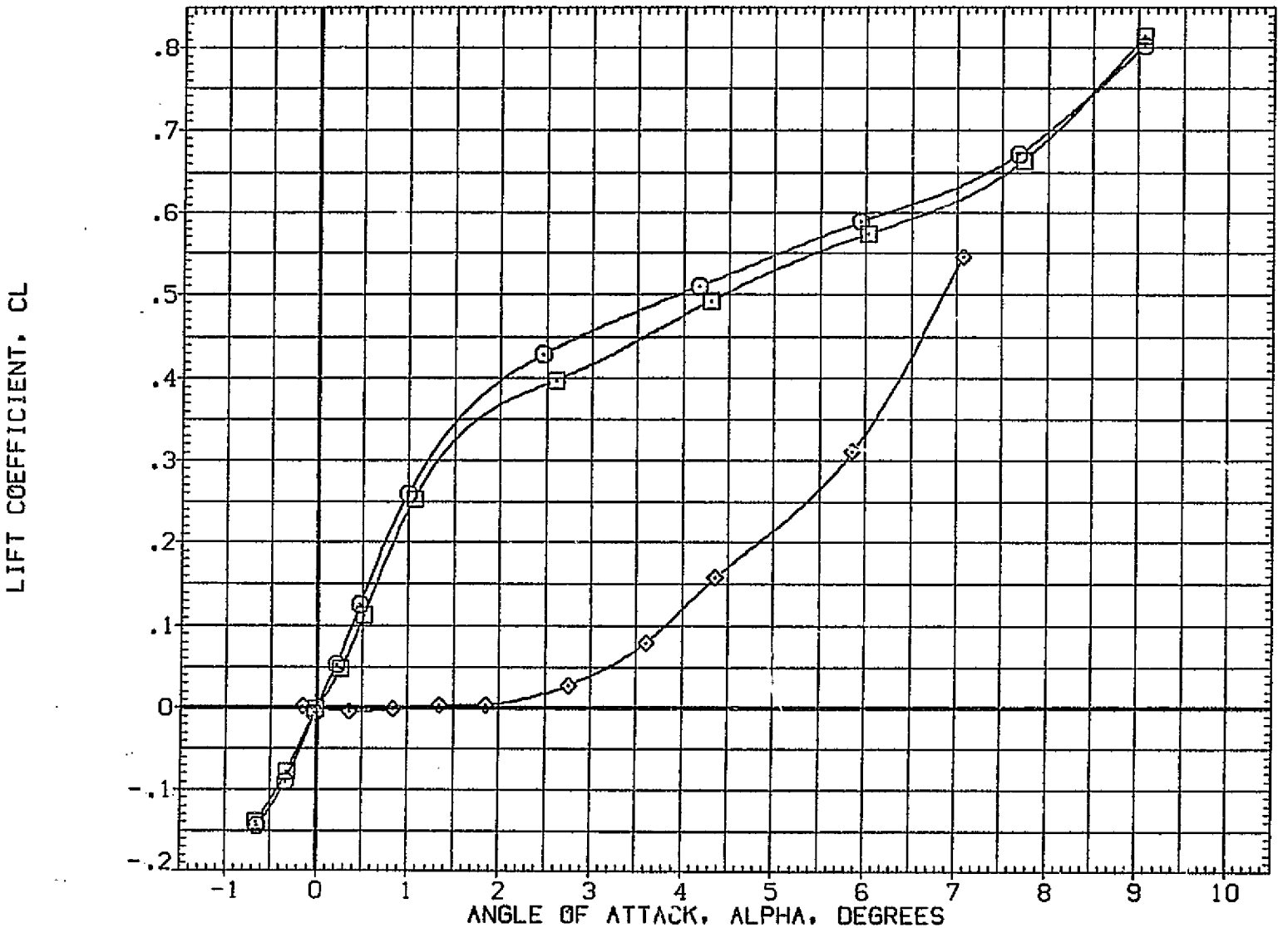

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

AIR (NLA003)

SYMBOL	MACH		PARAMETRIC VALUES
○	.399	RN	3.000
□	.602		
◇	.699		
△	.805		

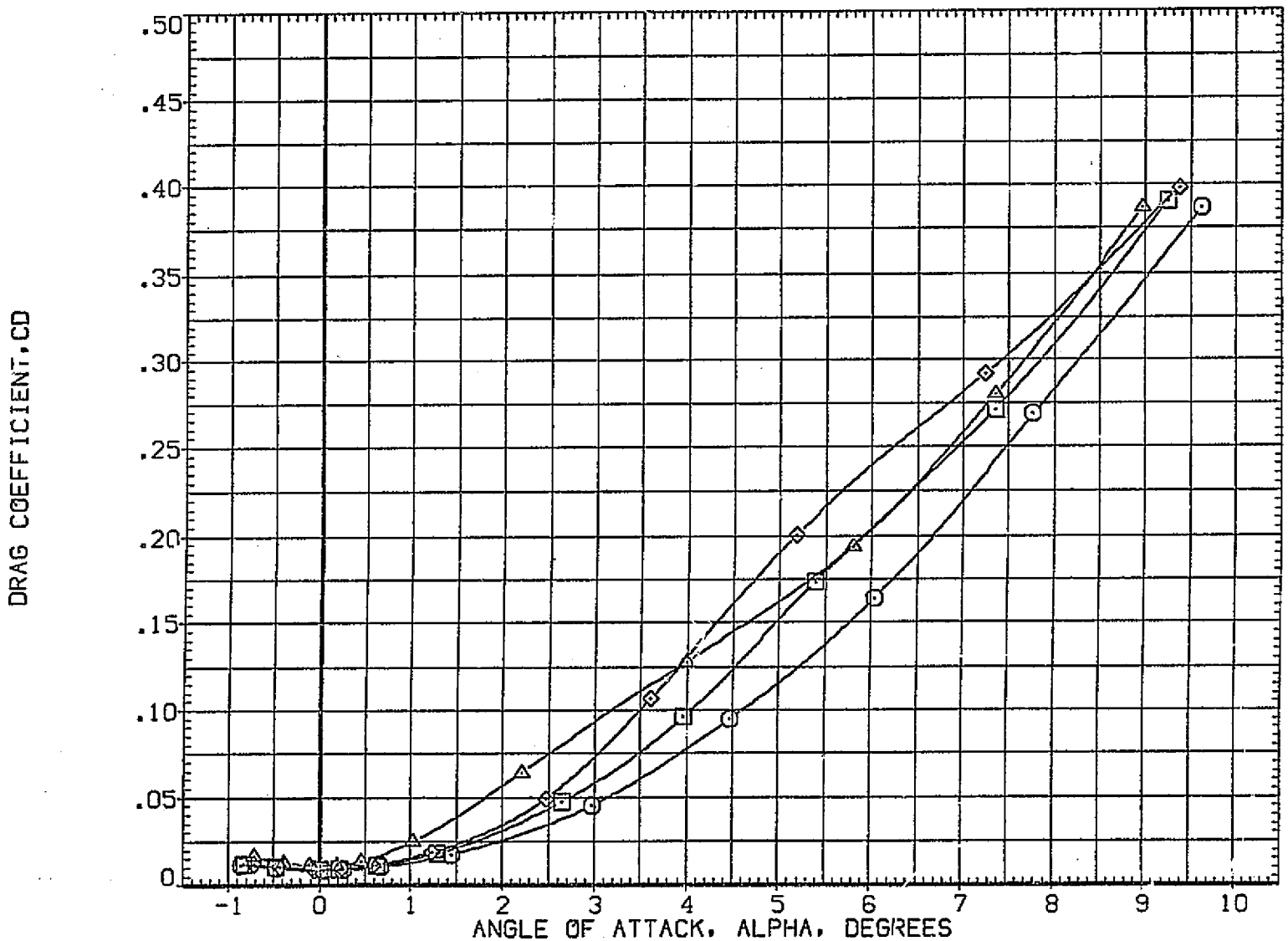

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

AIR (NLA003)

SYMBOL	MACH		PARAMETRIC VALUES
○	.823	RN	3.000
□	.832		
◇	.902		

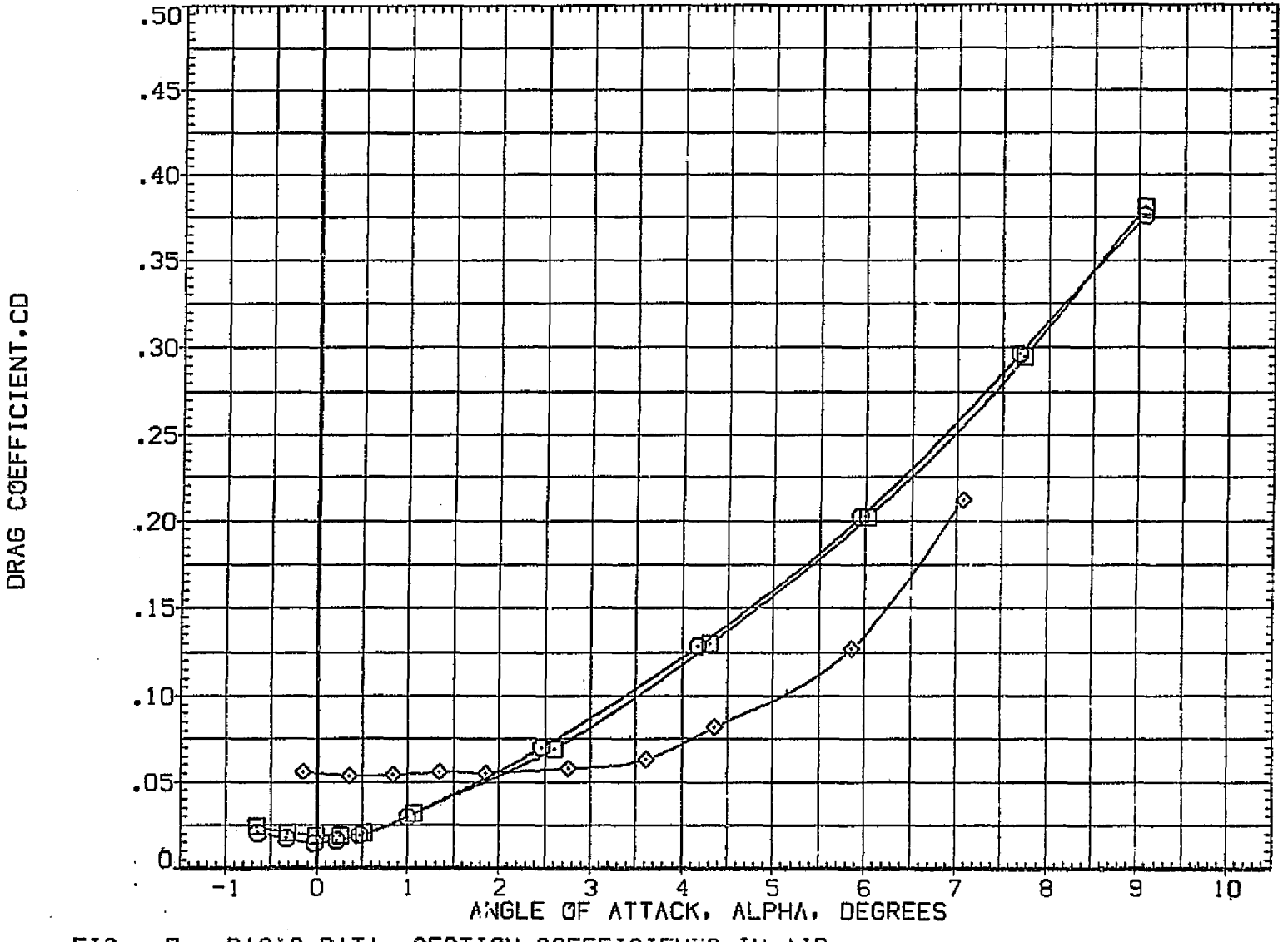

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

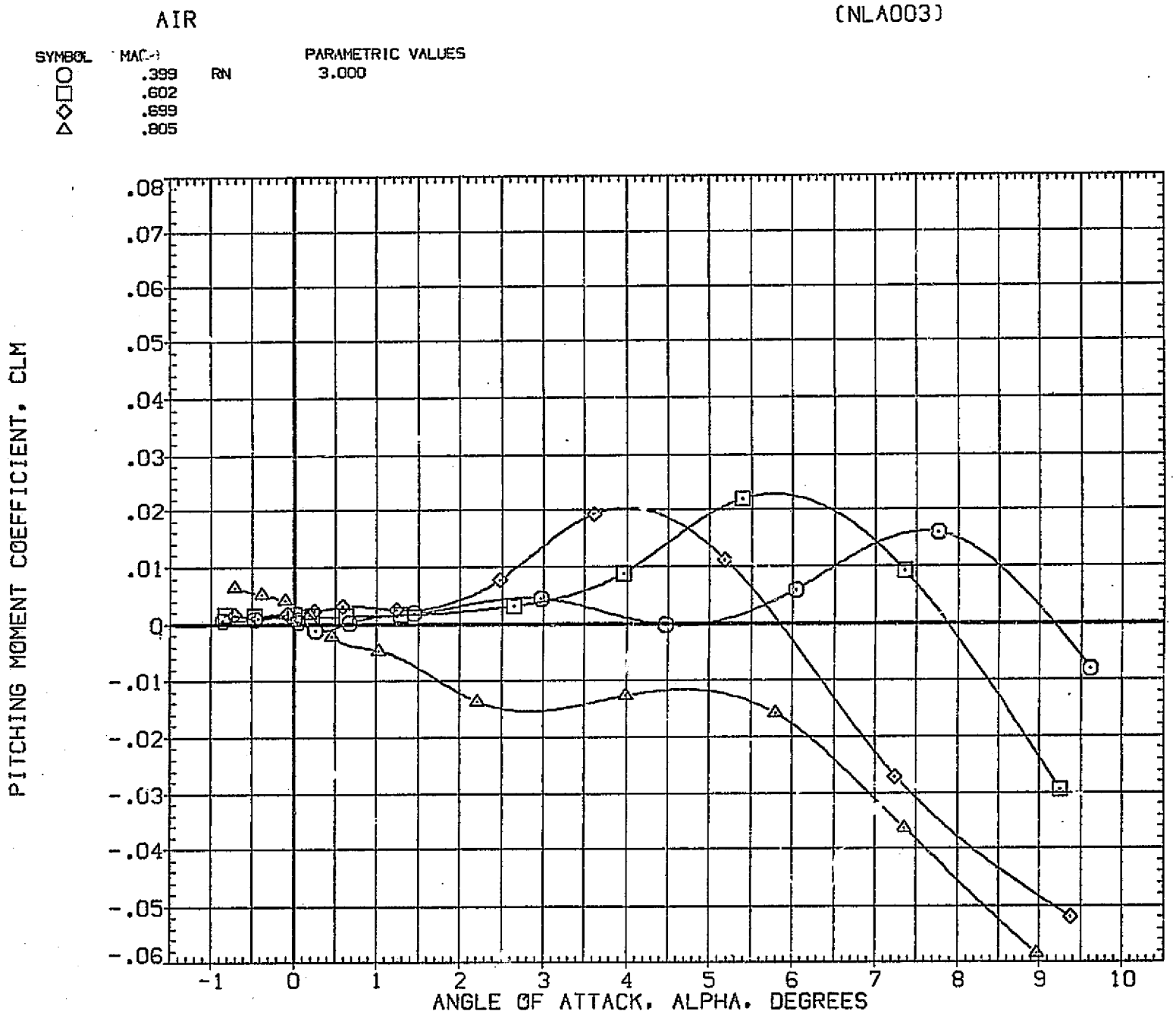

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

SYMBOL	MACH		PARAMETRIC VALUES
○	.823	RN	3.000
□	.832		
◇	.902		

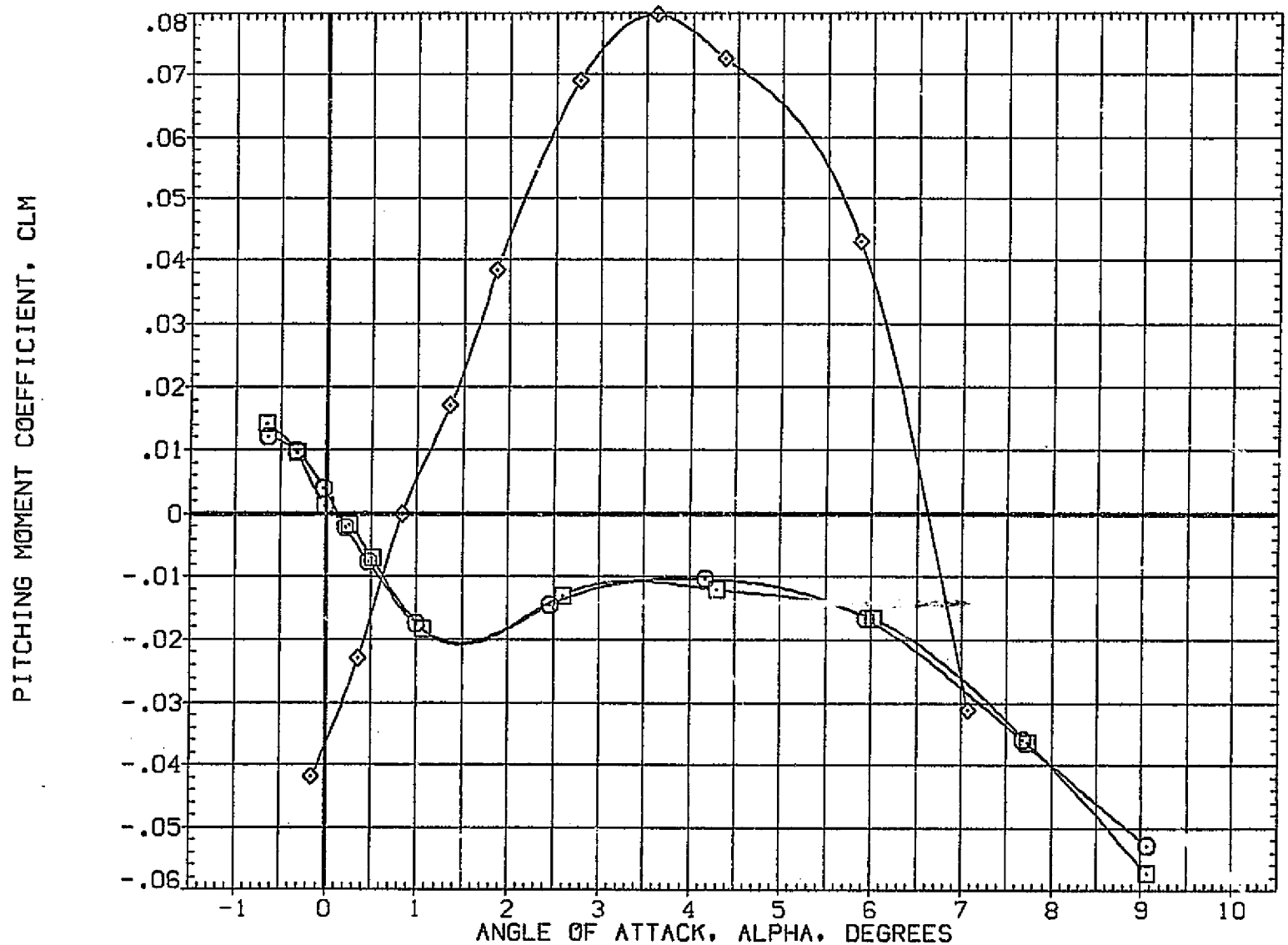

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

AIR

(NLA004)

SYMBOL	MACH		PARAMETRIC VALUES
○	.601	RN	3.450
□	.701		
◇	.811		
△	.902		

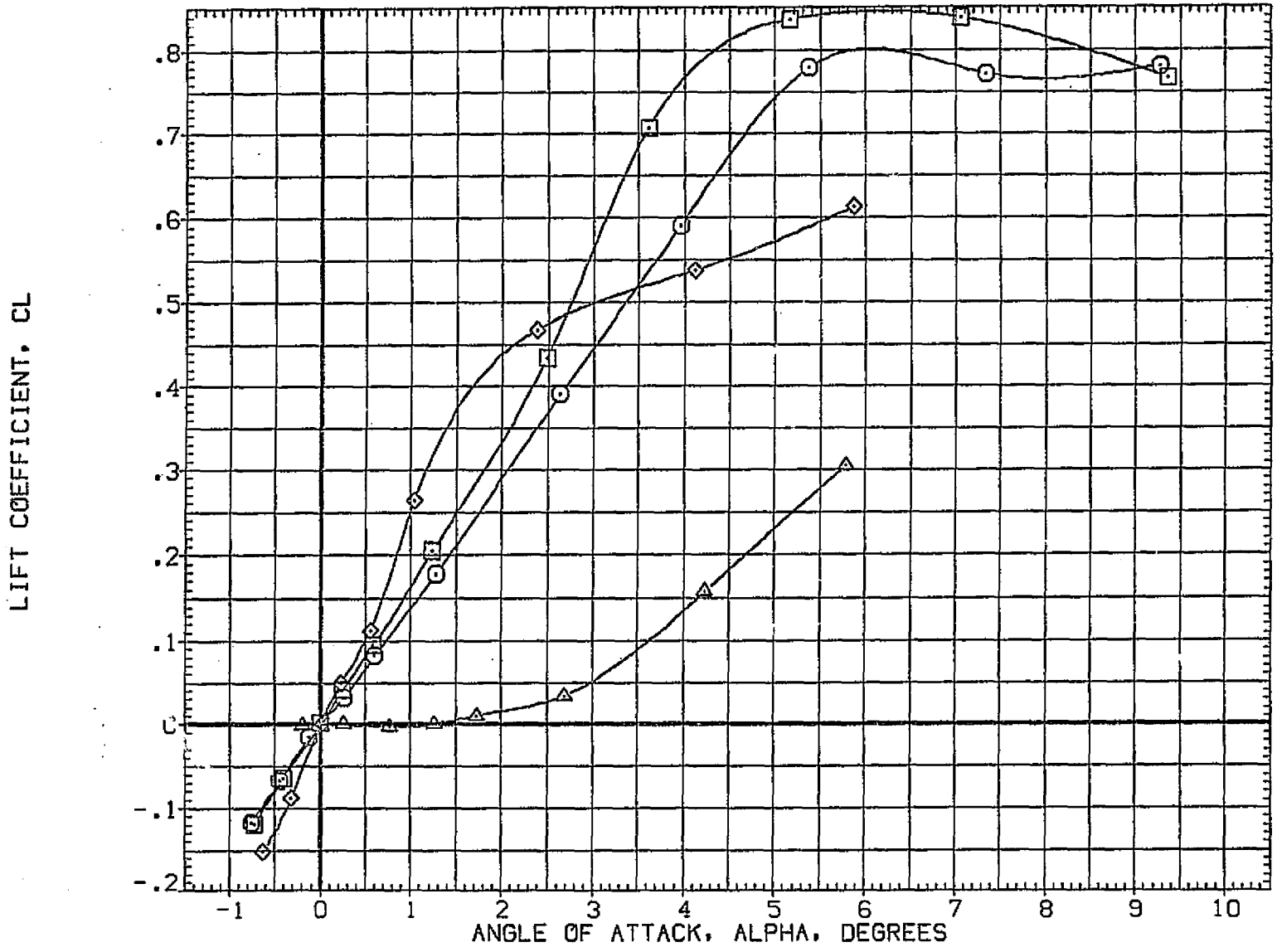

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

SYMBOL	MACH		PARAMETRIC VALUES
○	.601	RN	3.450
□	.701		
◇	.811		
△	.902		

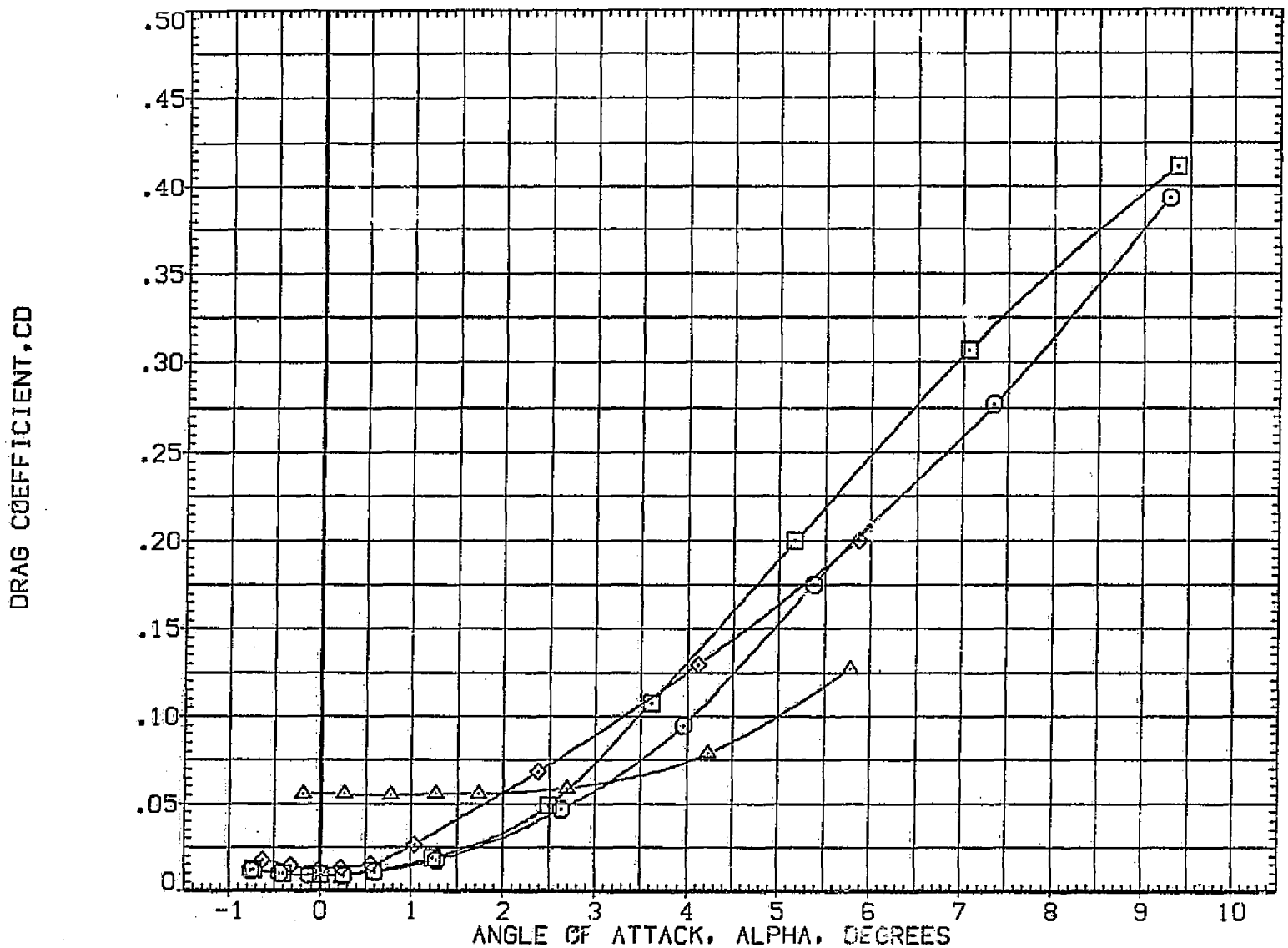

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

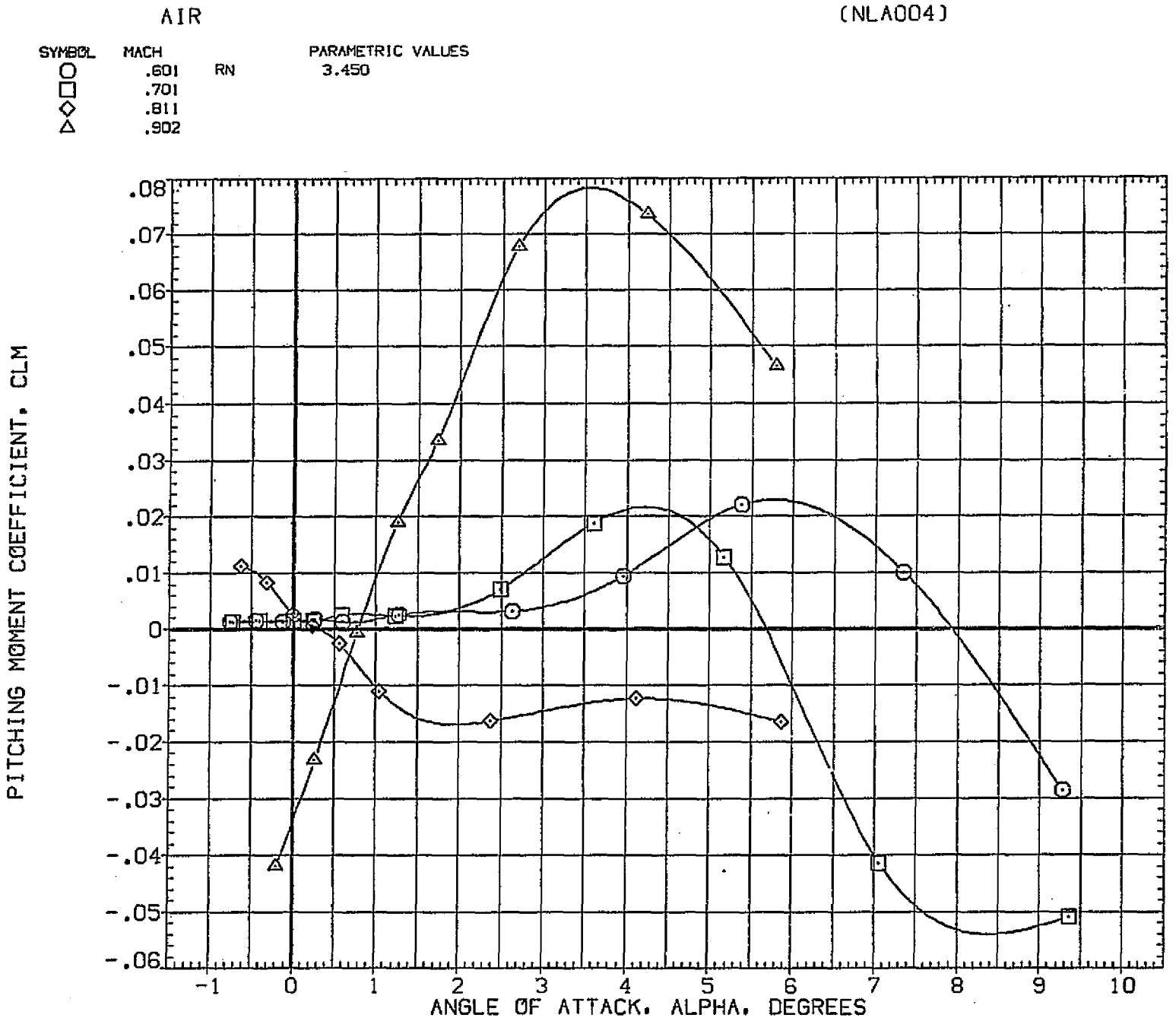

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

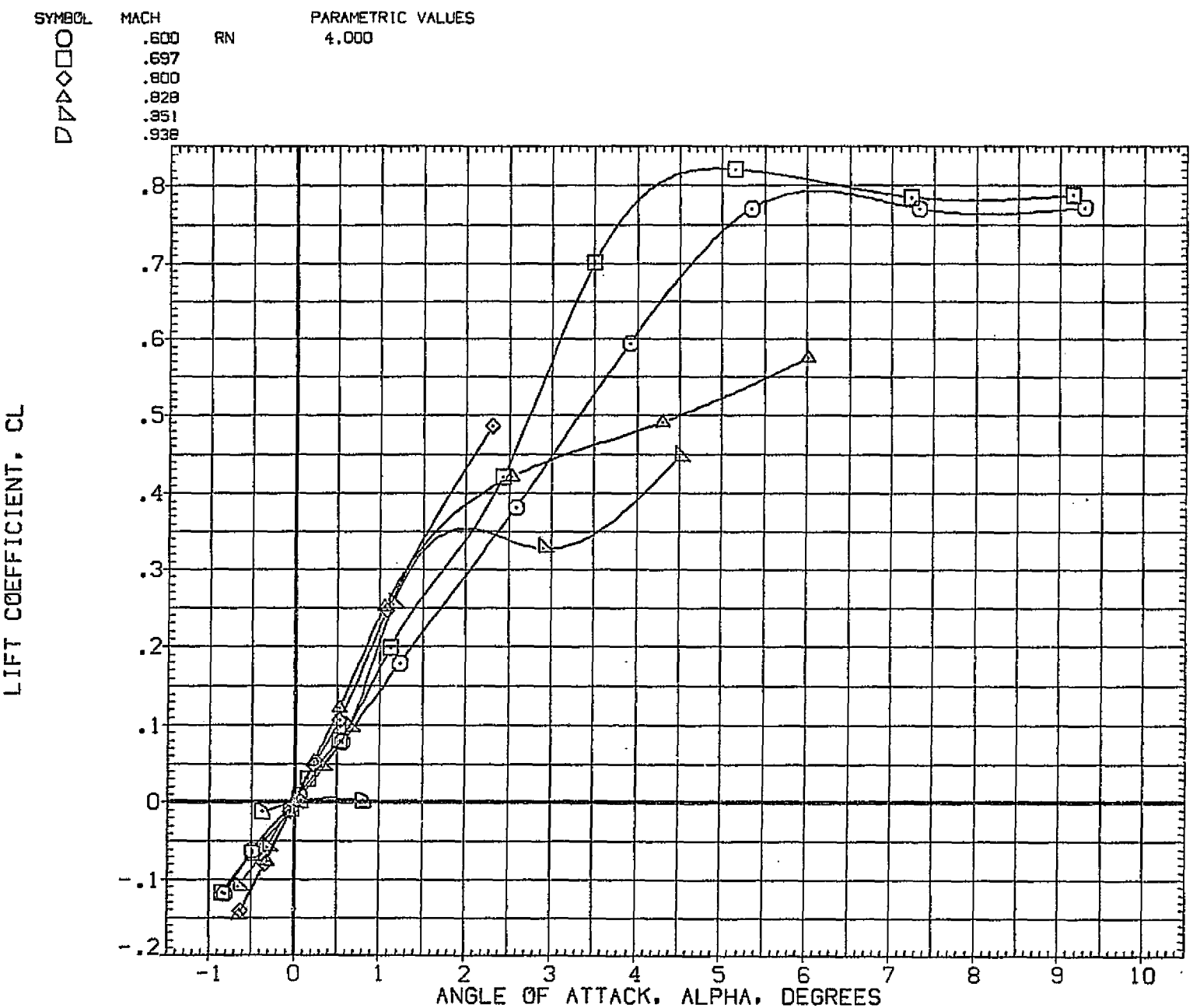

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

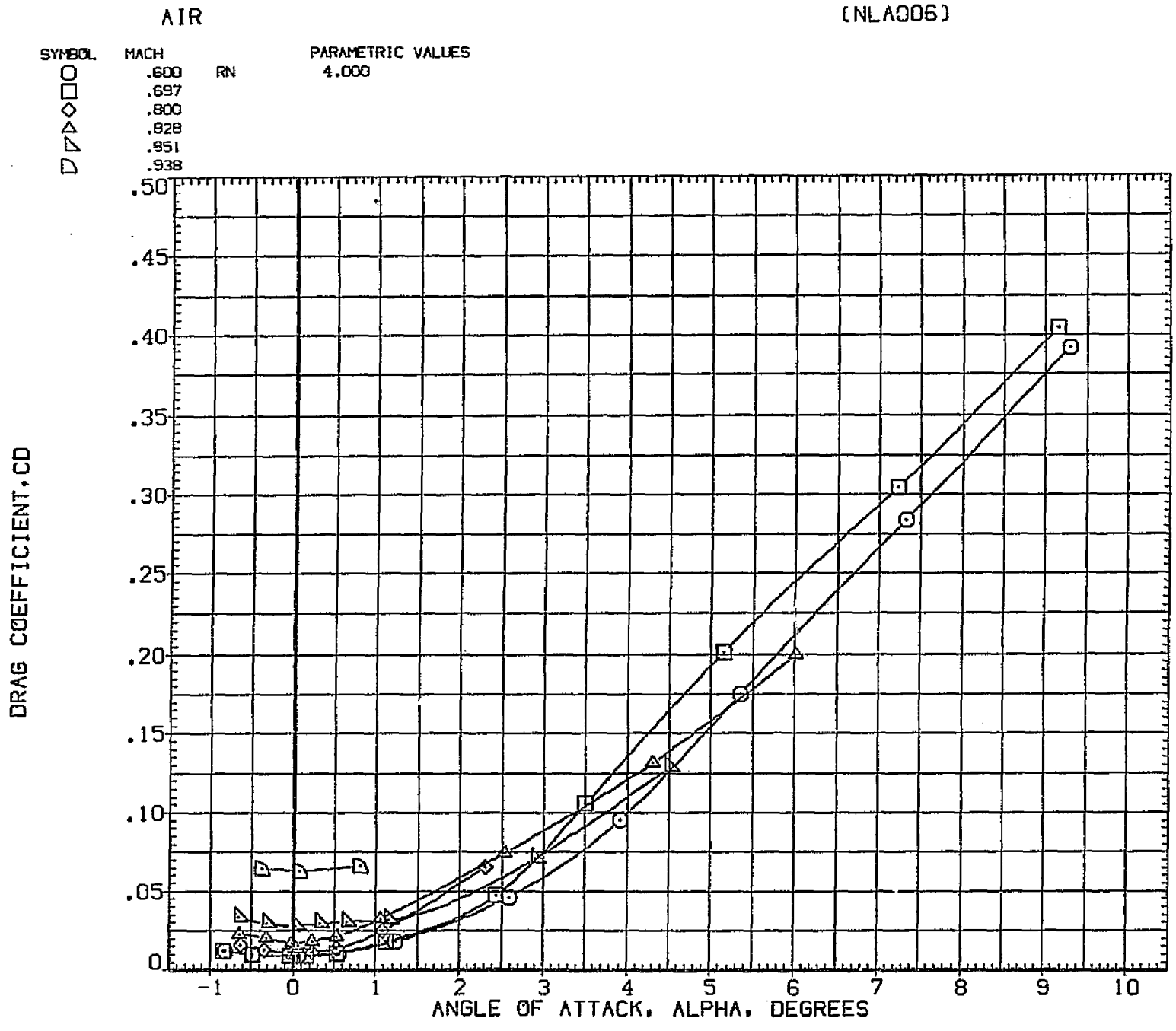

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

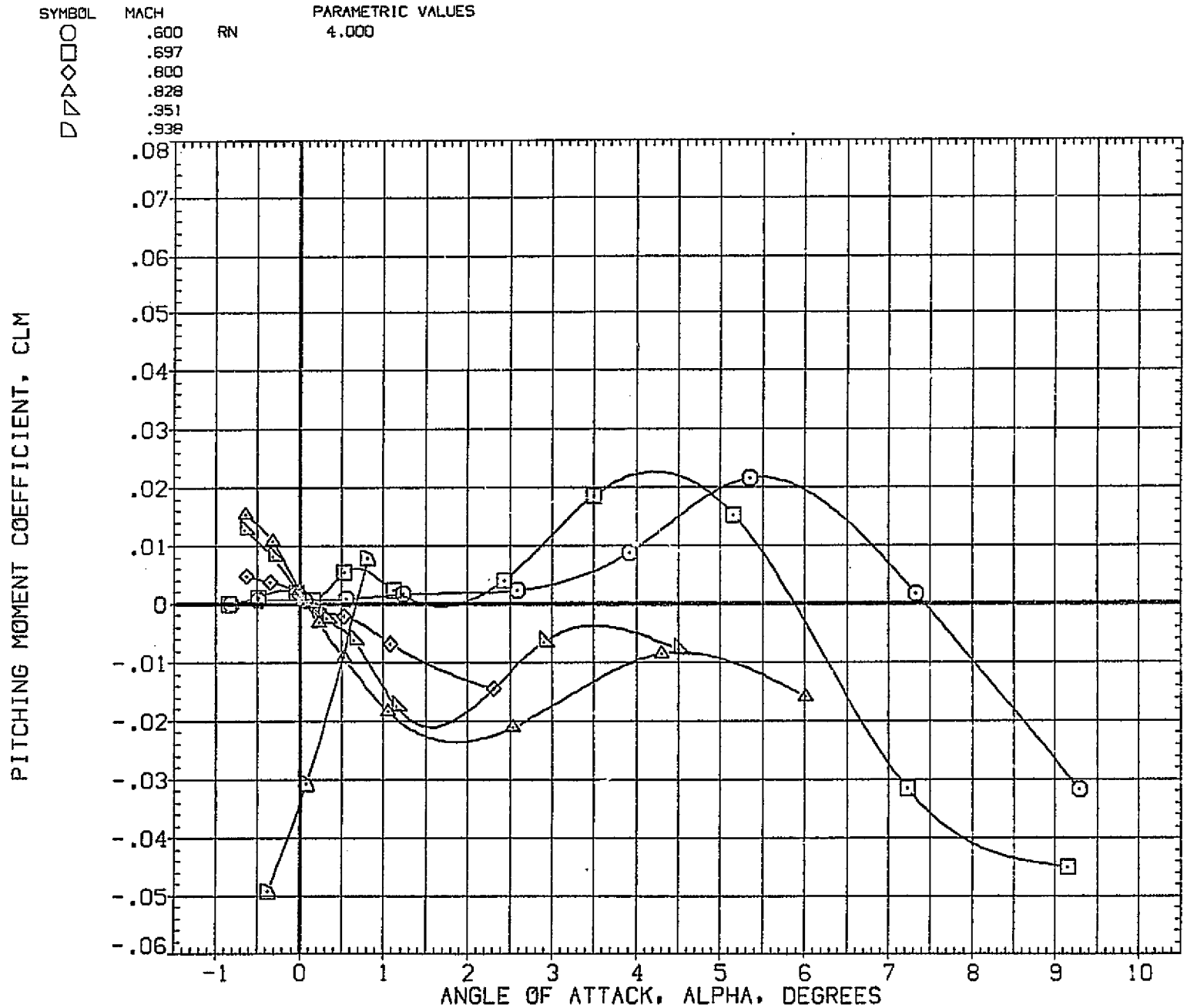

FIG. 7 BASIC DATA, SECTION COEFFICIENTS IN AIR

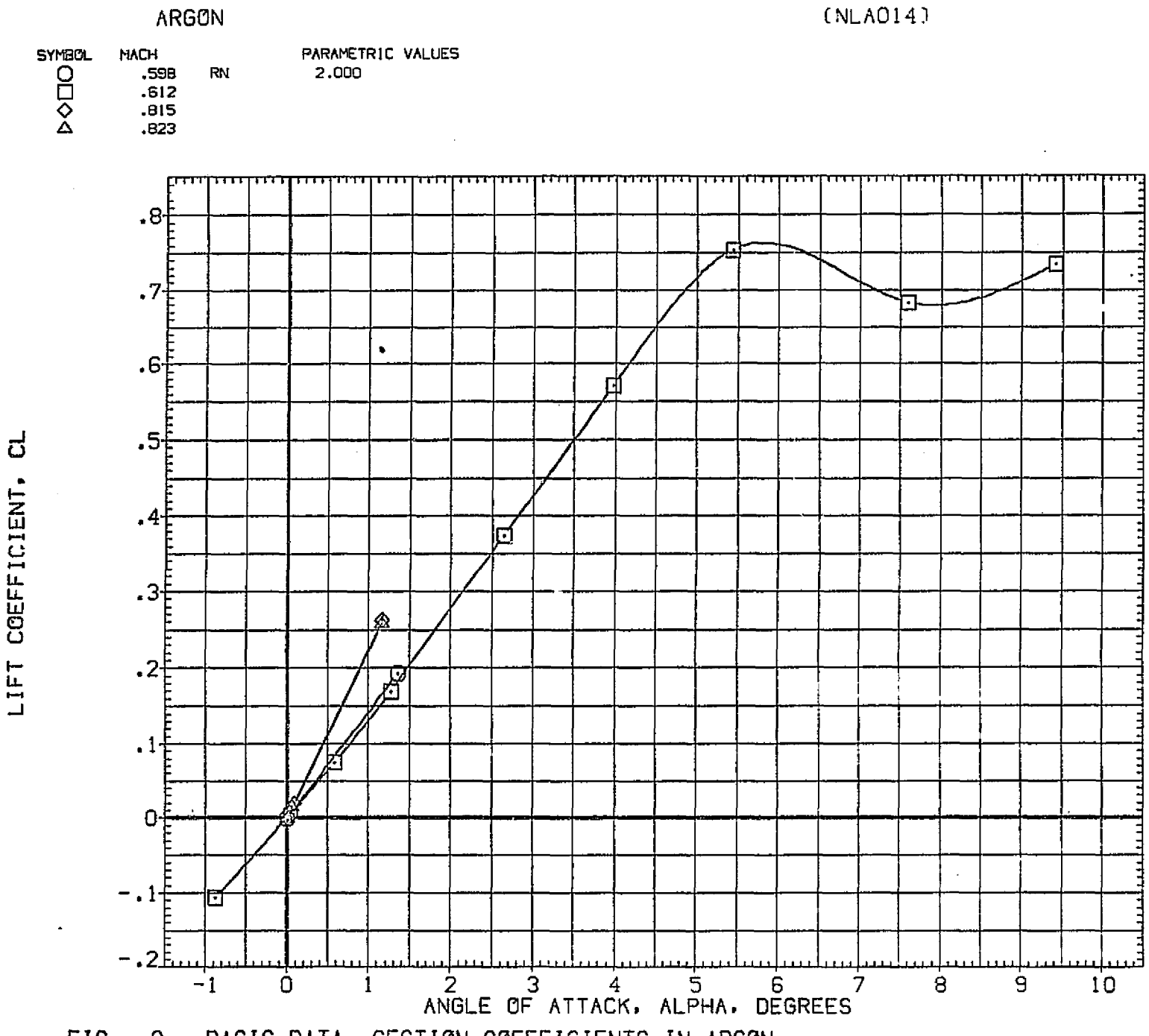

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

SYMBOL	MACH		PARAMETRIC VALUES
○	.840	RN	2.000
□	.844		
◇	.868		
△	.873		

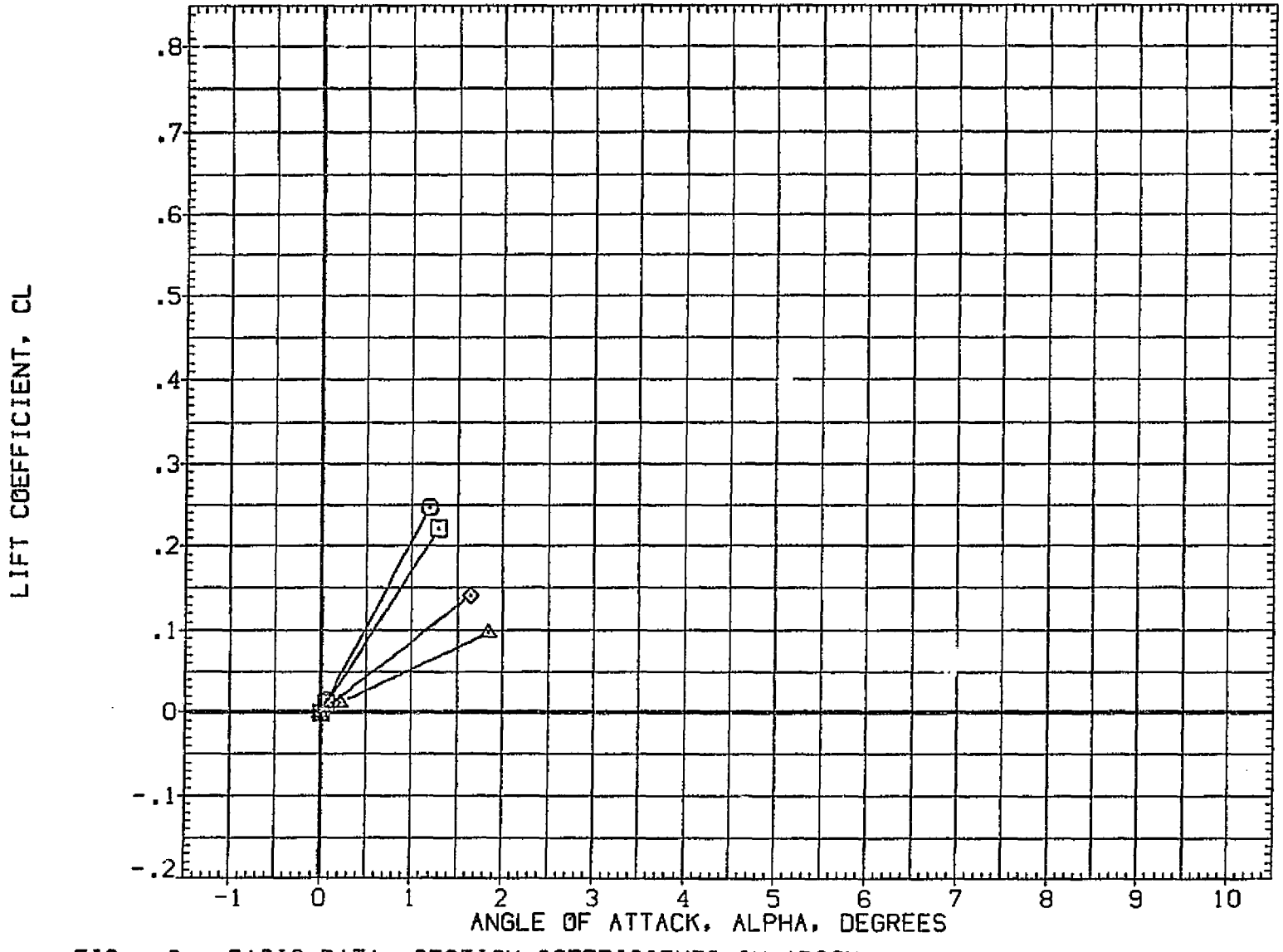

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

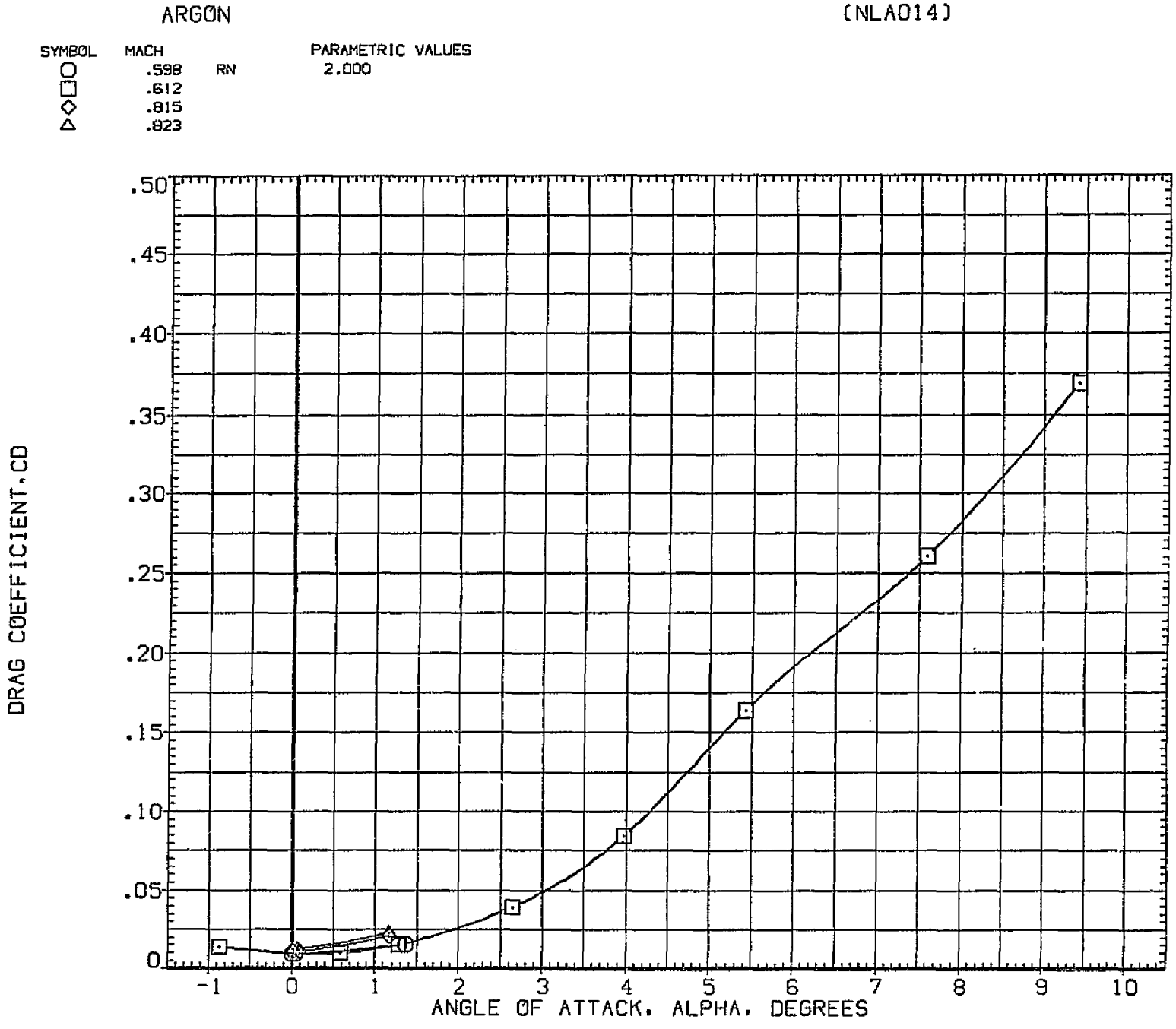

FIG. 8 BASIC DATA, SECTIØN CØEFFICIENTS IN ARGØN

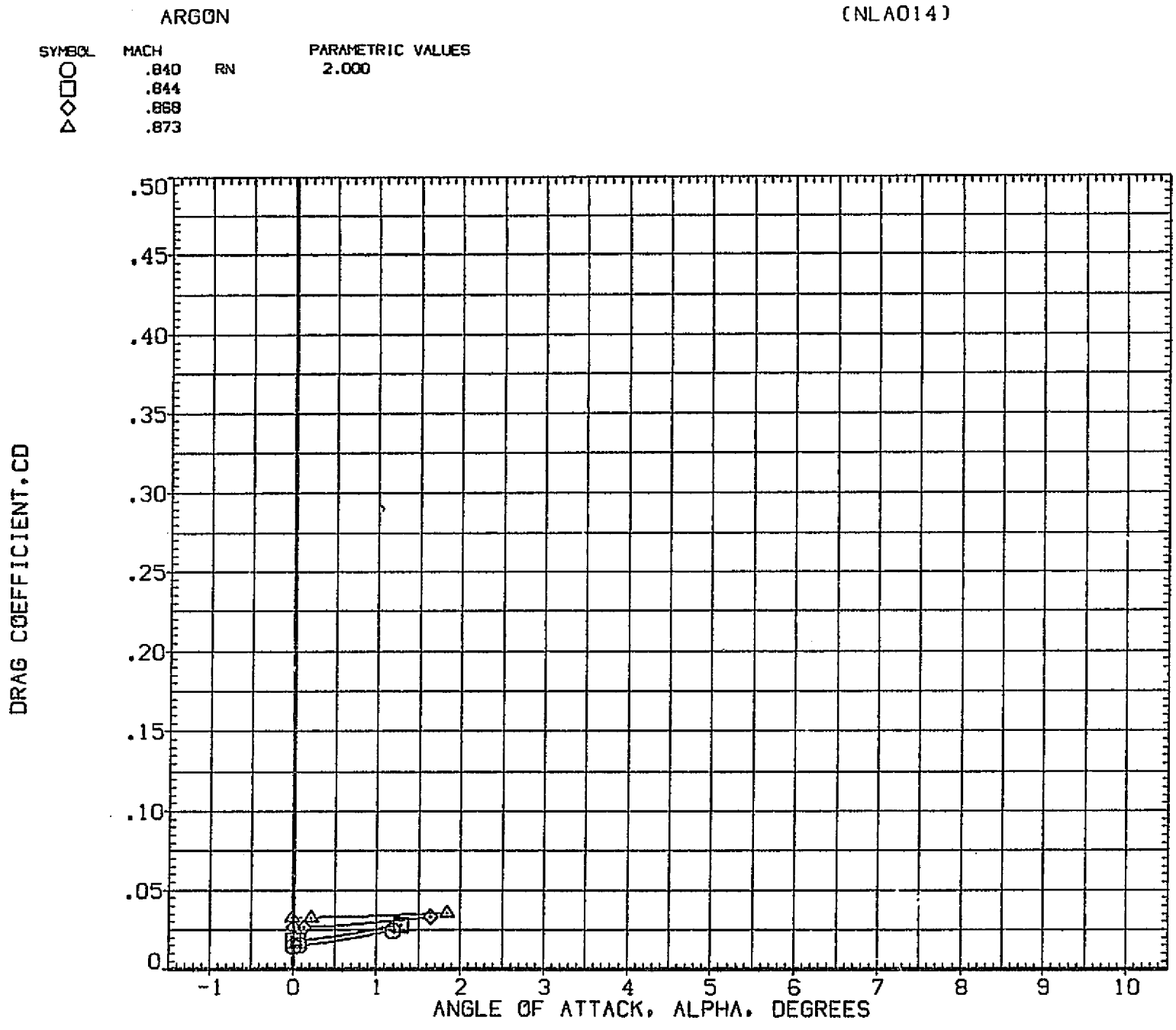

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

ARGØN (NLA014)

SYMBØL	MACH		PARAMETRIC VALUES
○	.598	RN	2.000
□	.612		
◇	.815		
△	.823		

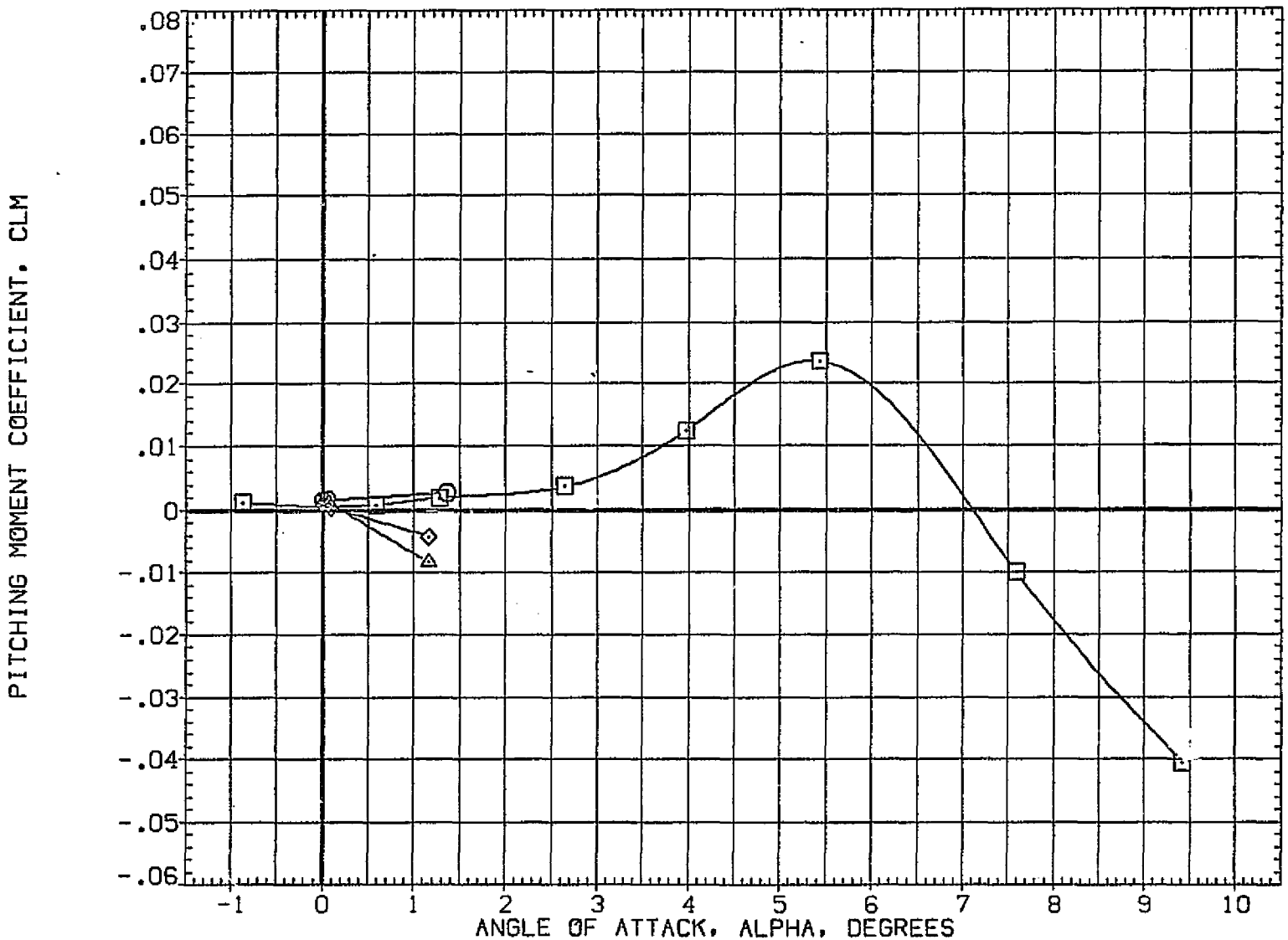

FIG. 8 BASIC DATA, SECTIØN CØEFFICIENTS IN ARGØN

SYMBOL	MACH		PARAMETRIC VALUES
○	.840	RN	2.000
□	.844		
◇	.868		
△	.873		

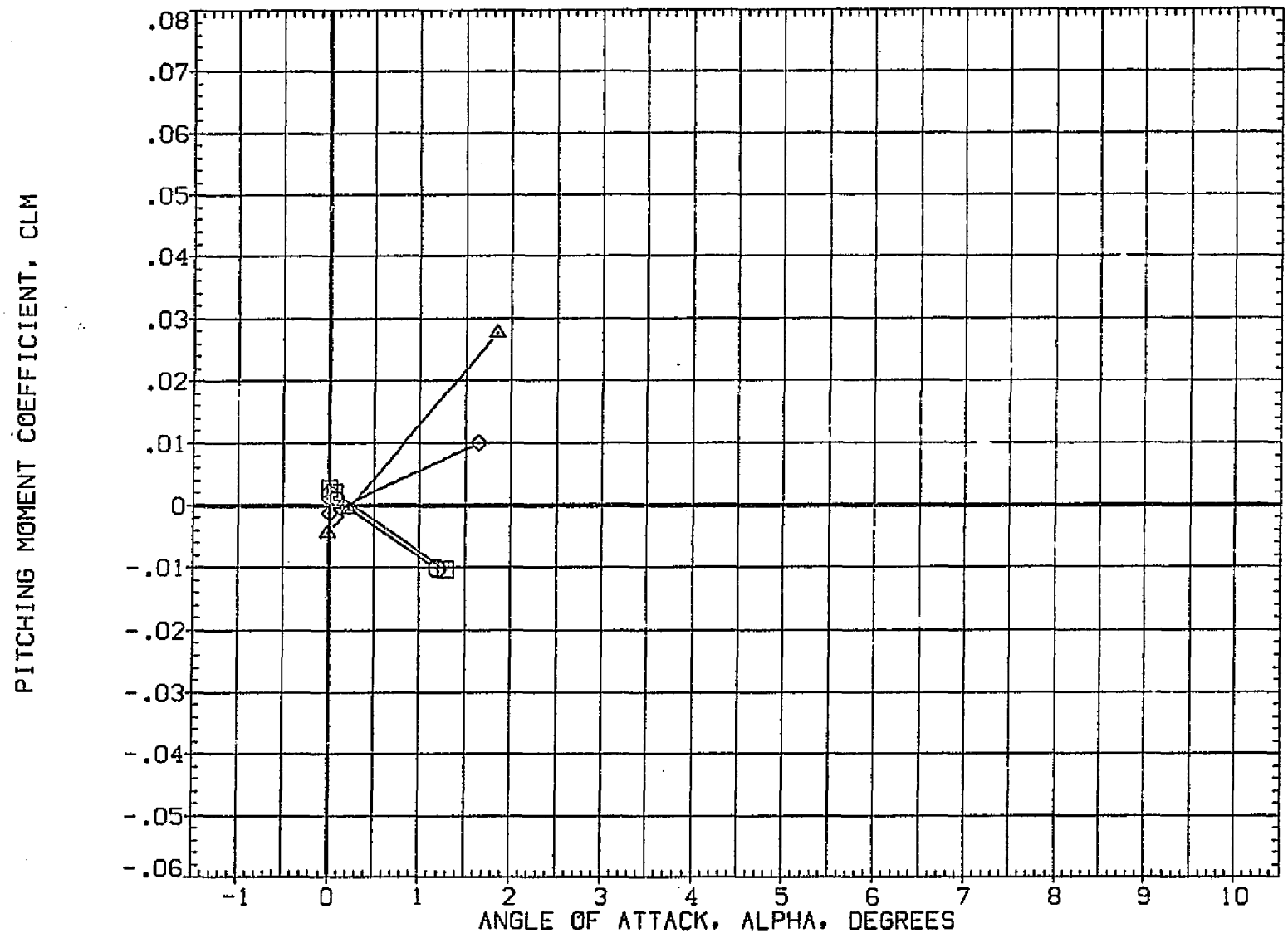

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

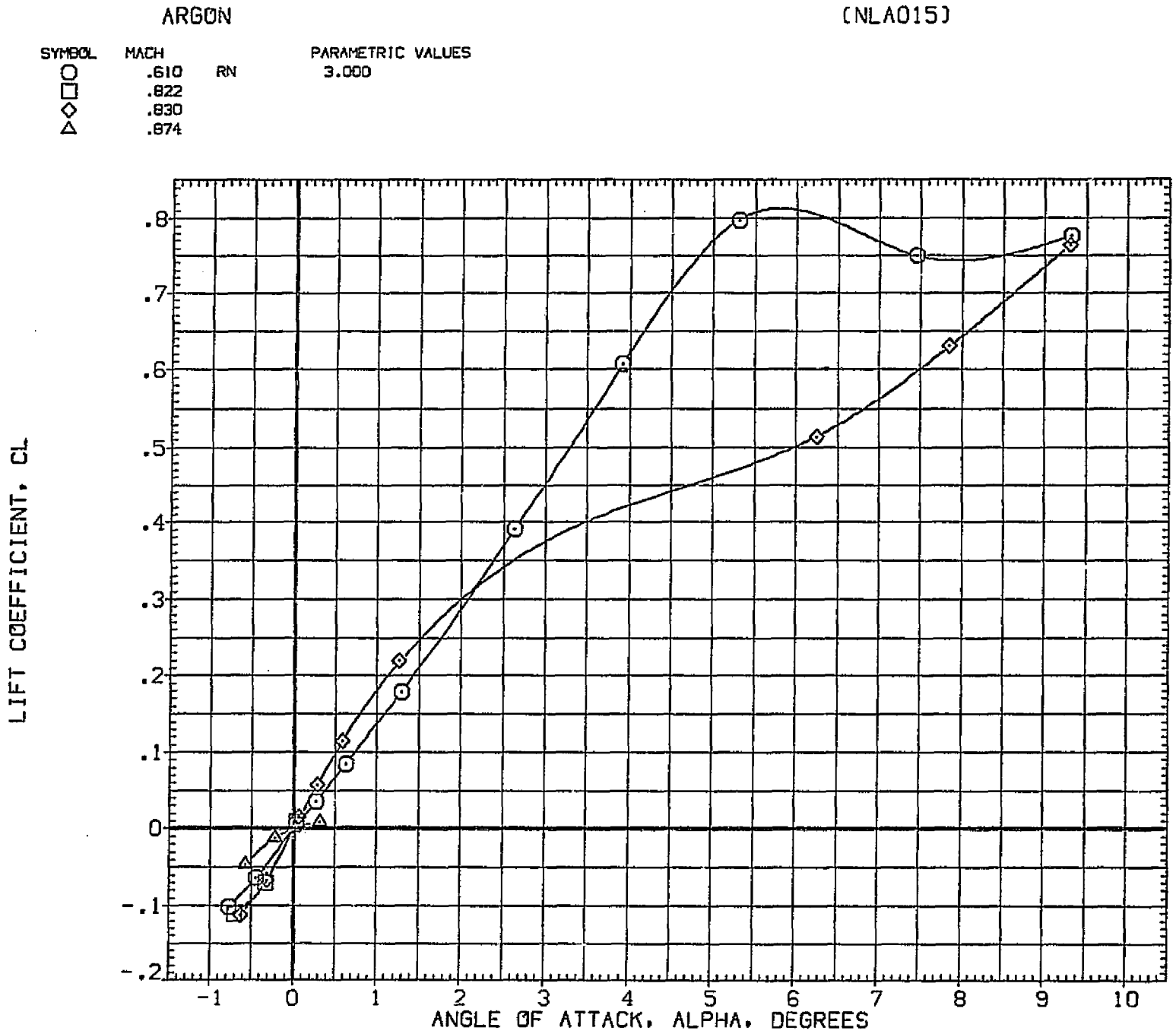

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

SYMBOL MACH PARAMETRIC VALUES
○ .610 RN 3.000
□ .822
◇ .830
△ .874

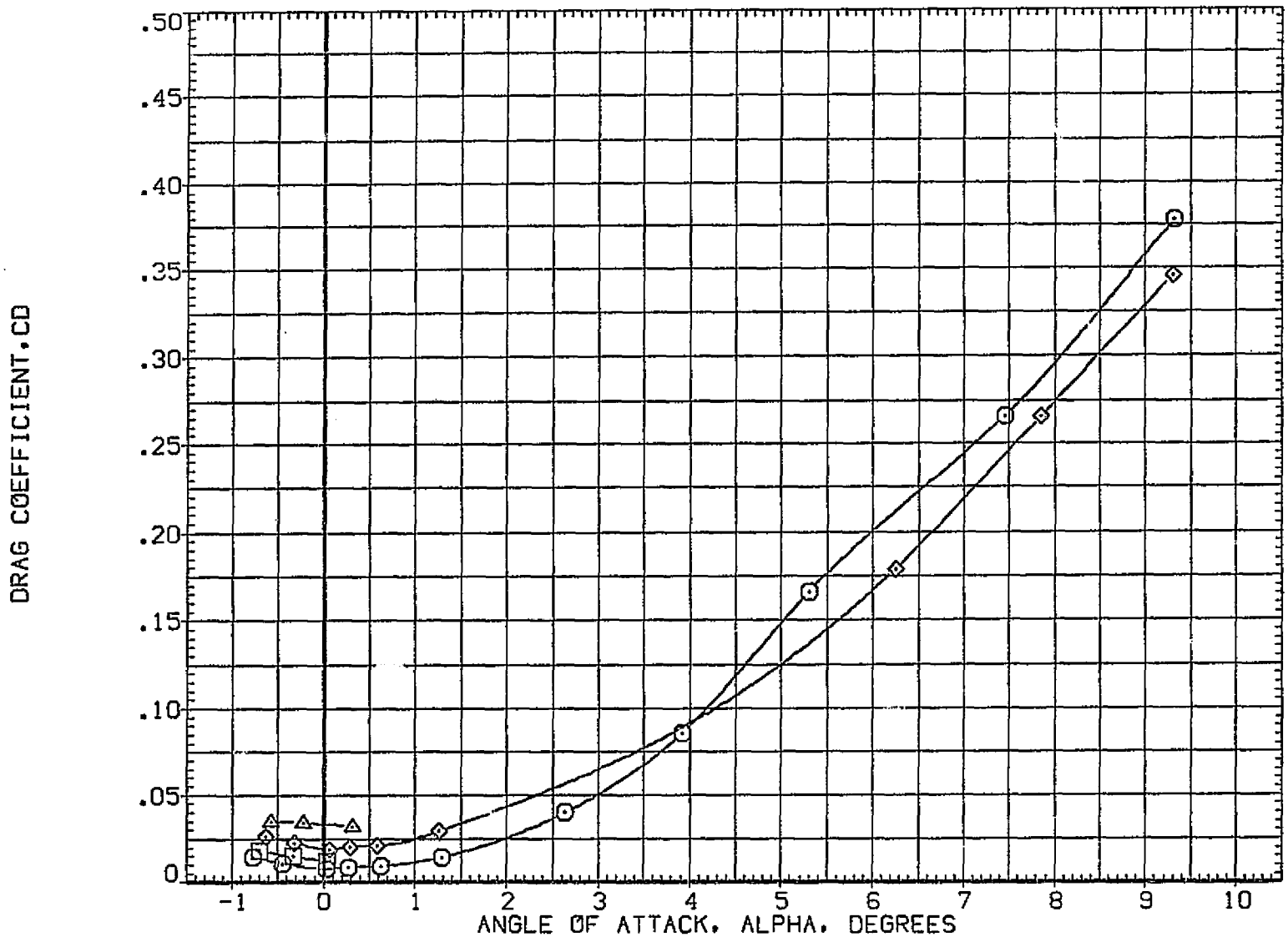

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

ARGON (NLA015)

SYMBOL	MACH		PARAMETRIC VALUES
○	.610	RN	3.000
□	.822		
◇	.830		
△	.874		

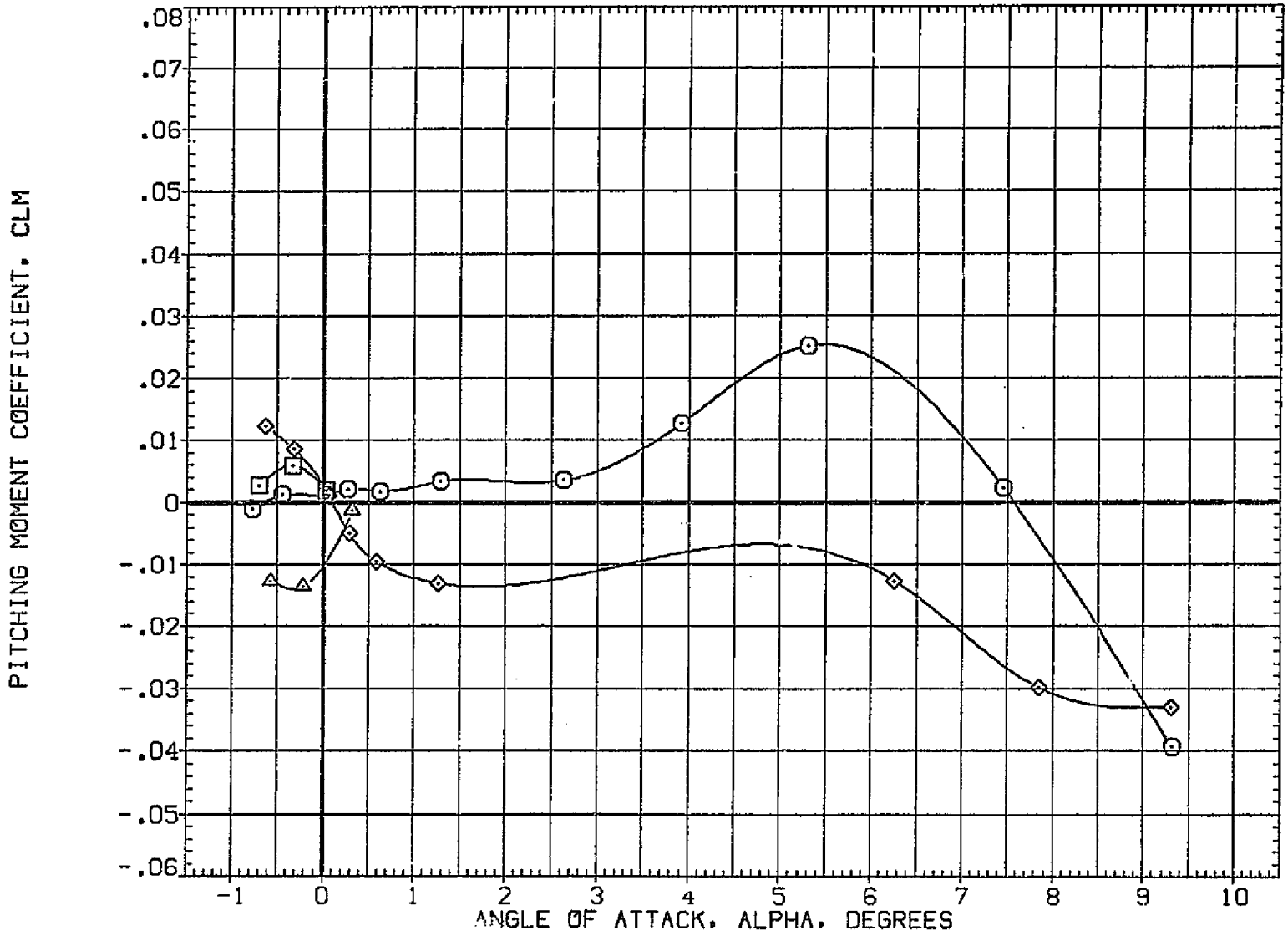

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

ARGØN (NLA016)

SYMBOL	MACH		PARAMETRIC VALUES
○	.604	RN	3.950
□	.861		

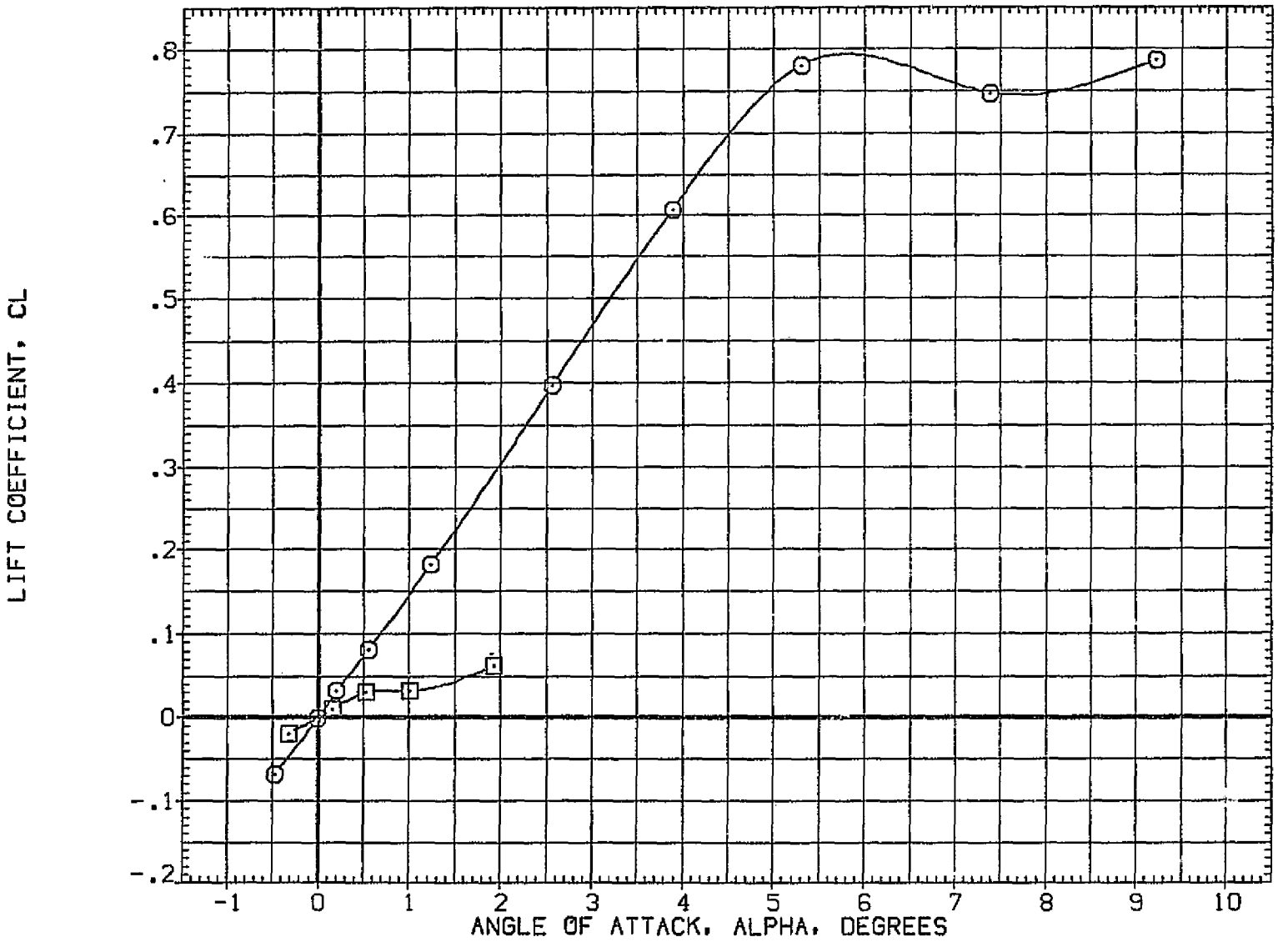

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGØN

ARGON (NLA016)

SYMBOL	MACH		PARAMETRIC VALUES
○	.604	RN	3.950
□	.861		

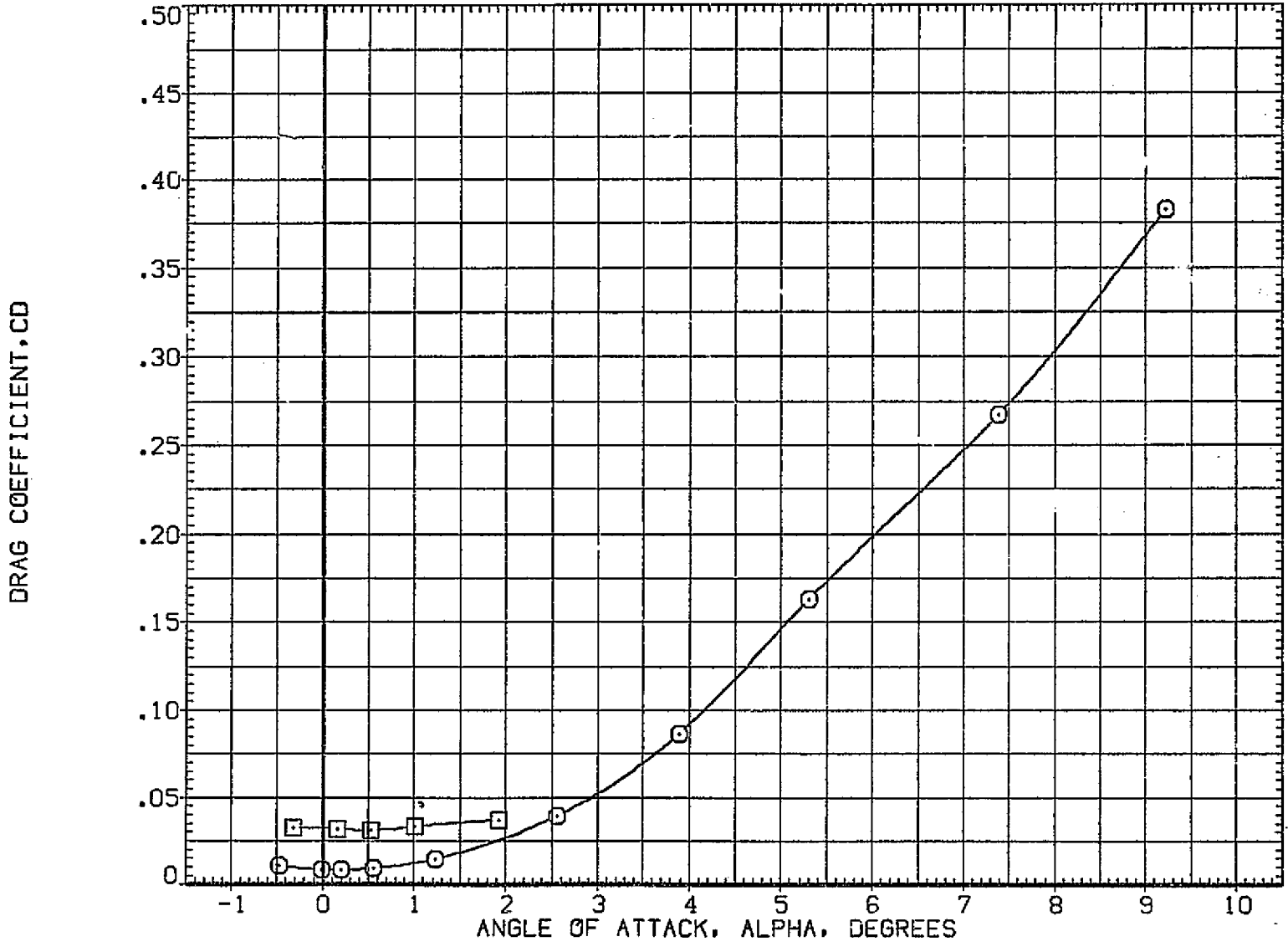

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

ARGON (NLA016)

SYMBOL	MACH		PARAMETRIC VALUES
○	.604	RN	3.950
□	.861		

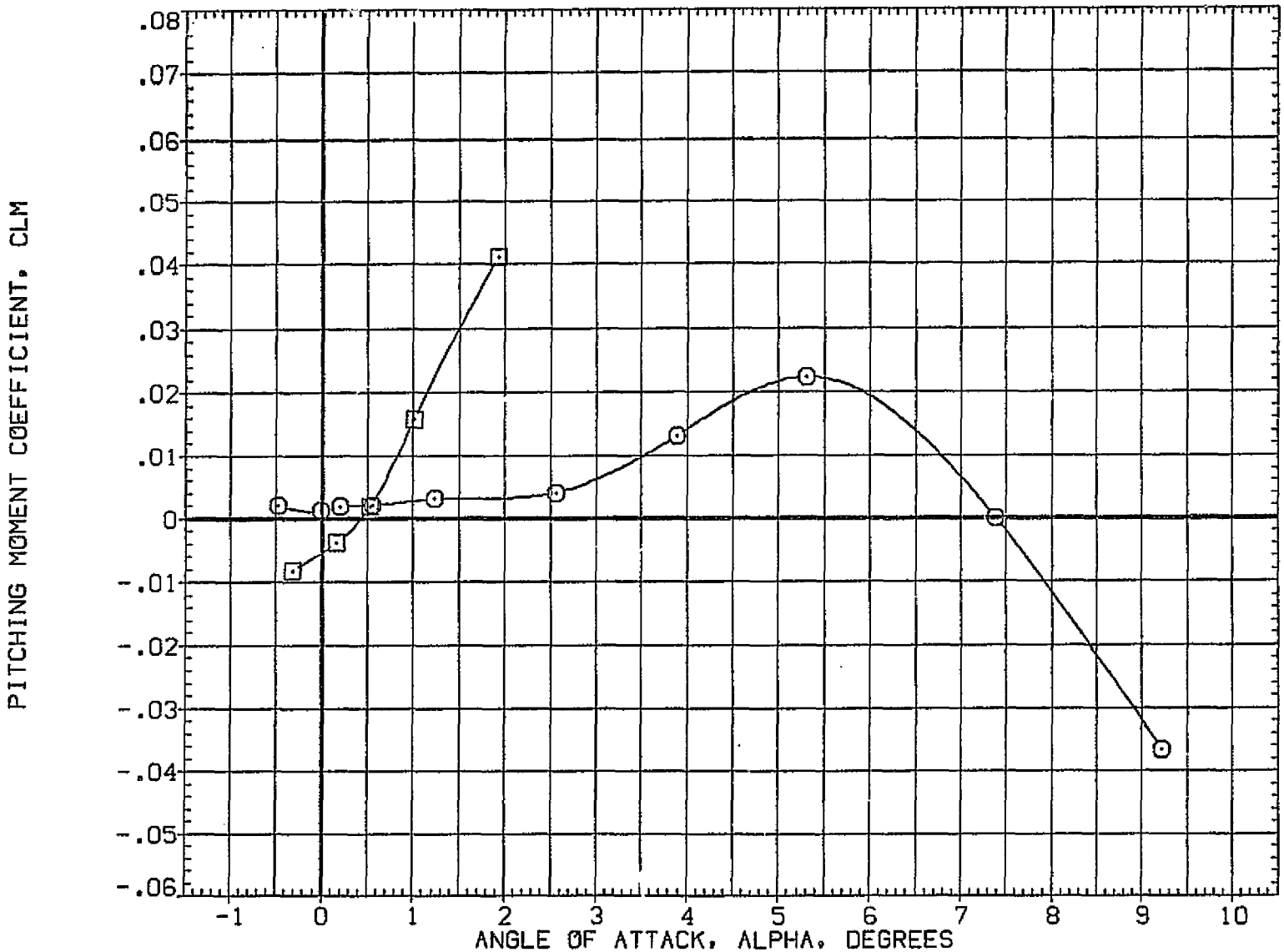

FIG. 8 BASIC DATA, SECTION COEFFICIENTS IN ARGON

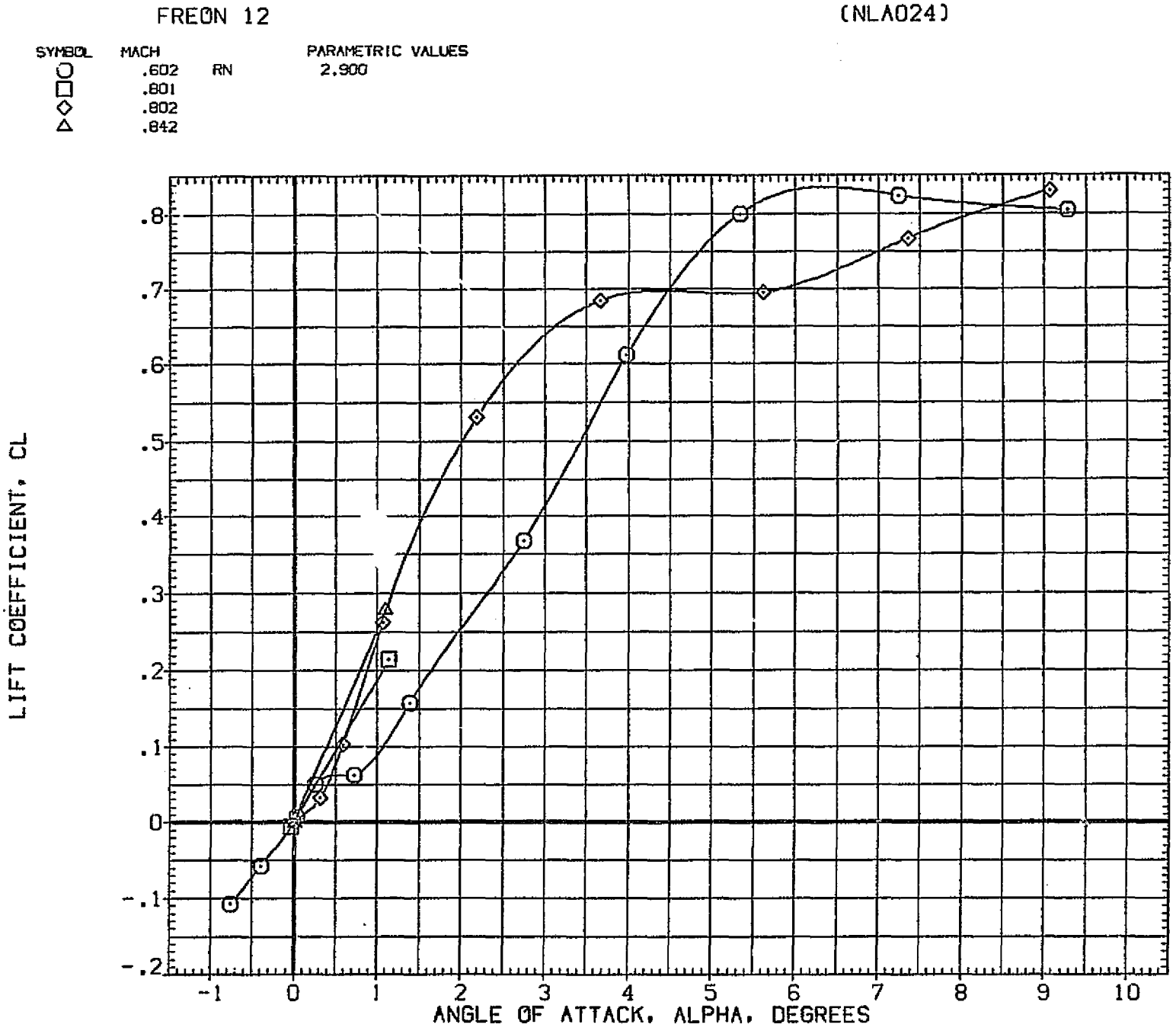

FIG. 9 BASIC DATA, SECTION COEFFICIENTS IN FREON 12

FREON 12

SYMBOL	MACH		PARAMETRIC VALUES
○	.602	RN	2.900
□	.801		
◇	.802		
△	.842		

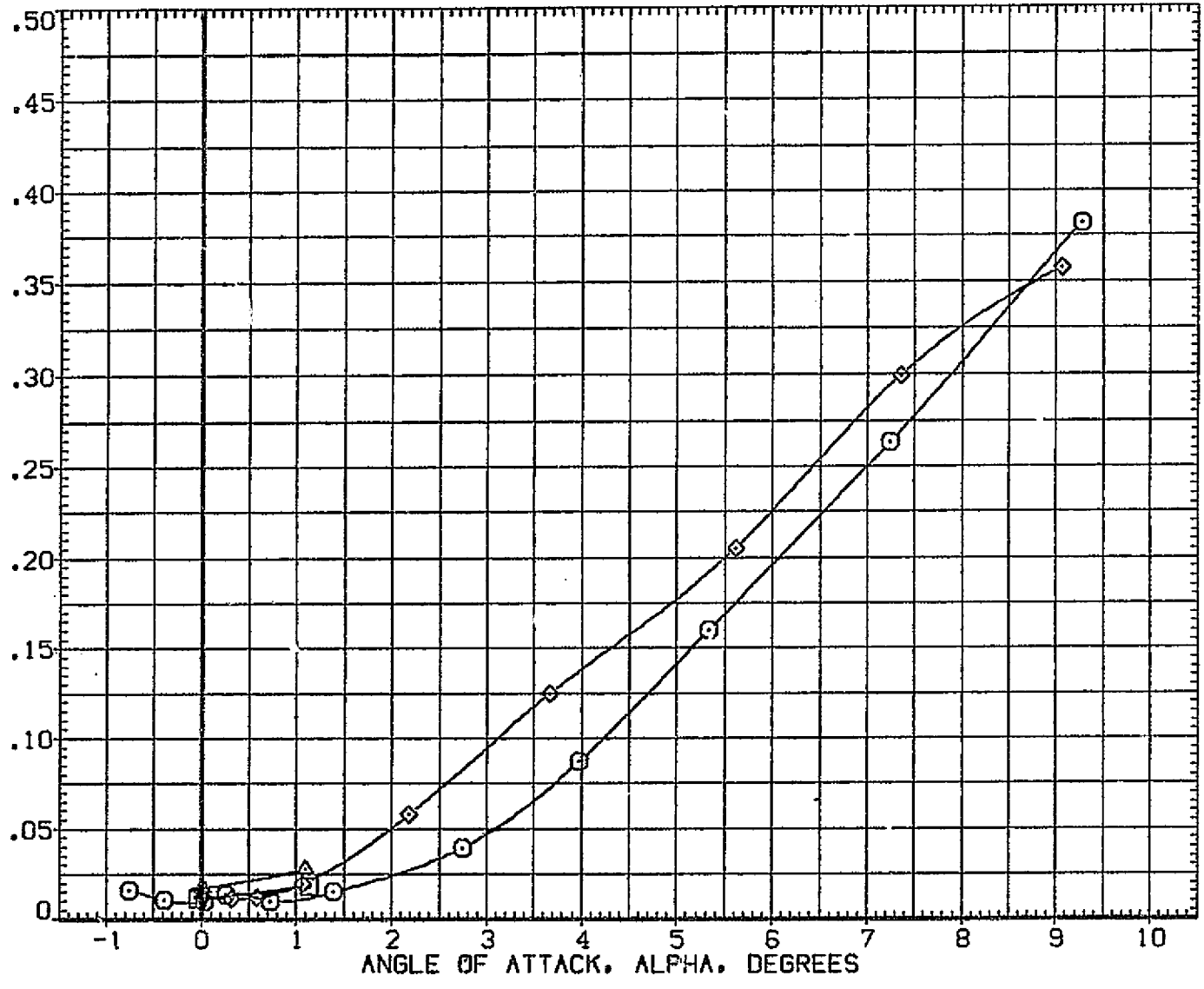

FIG. 9 BASIC DATA, SECTION COEFFICIENTS IN FREON 12

FREON 12 (NLA024)

SYMBOL	MACH		PARAMETRIC VALUES
○	.602	RN	2.900
□	.801		
◇	.802		
△	.842		

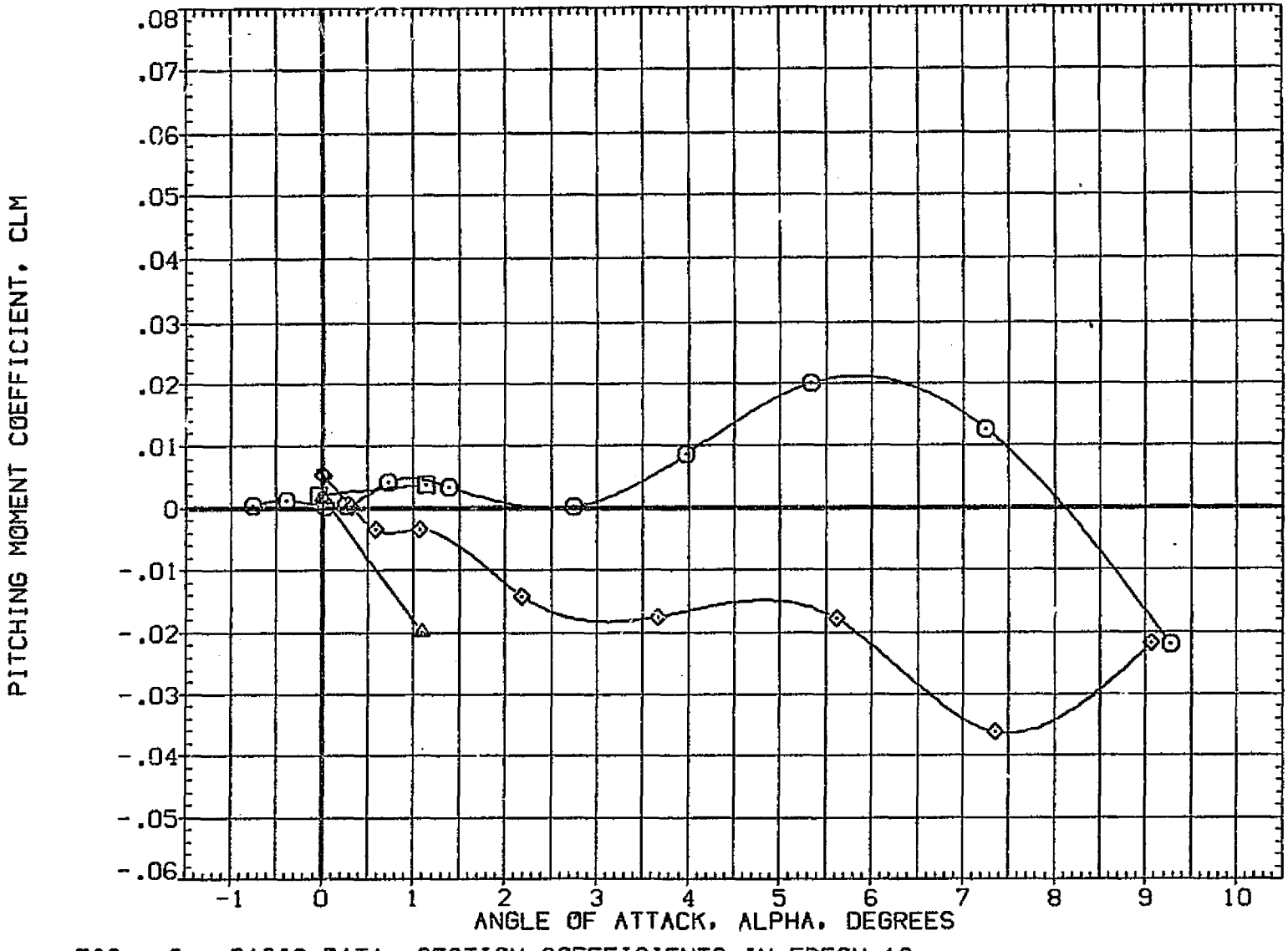

FIG. 9 BASIC DATA, SECTION COEFFICIENTS IN FREON 12

FREON 12 (NLA025)

SYMBOL	MACH		PARAMETRIC VALUES
○	.595	RN	6.300
□	.618		
◇	.786		

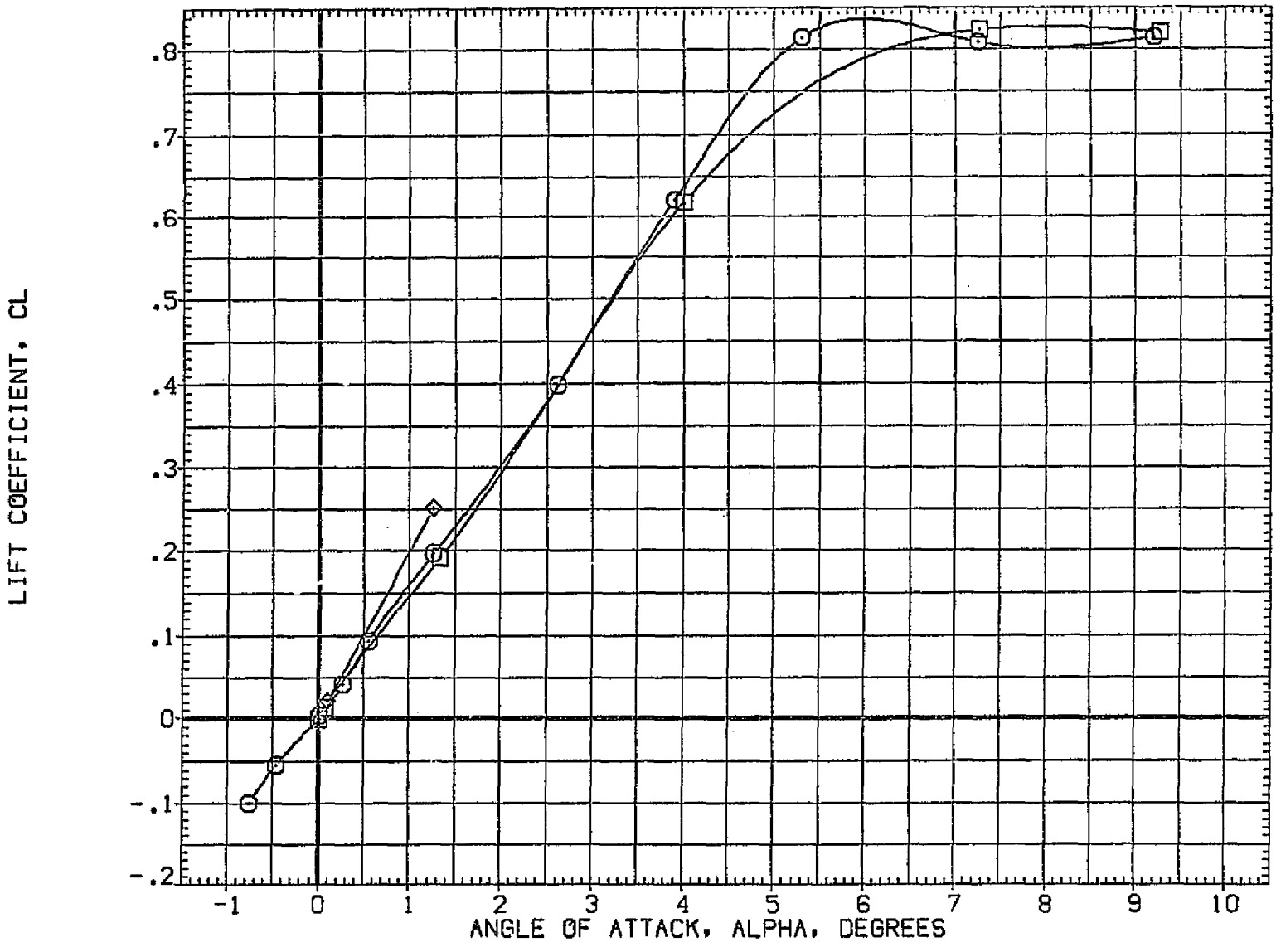

FIG. 9 BASIC DATA, SECTION COEFFICIENTS IN FREON 12

FREON 12 (NLA025)

SYMBOL	MACH		PARAMETRIC VALUES
○	.595	RN	6.300
□	.618		
◇	.786		

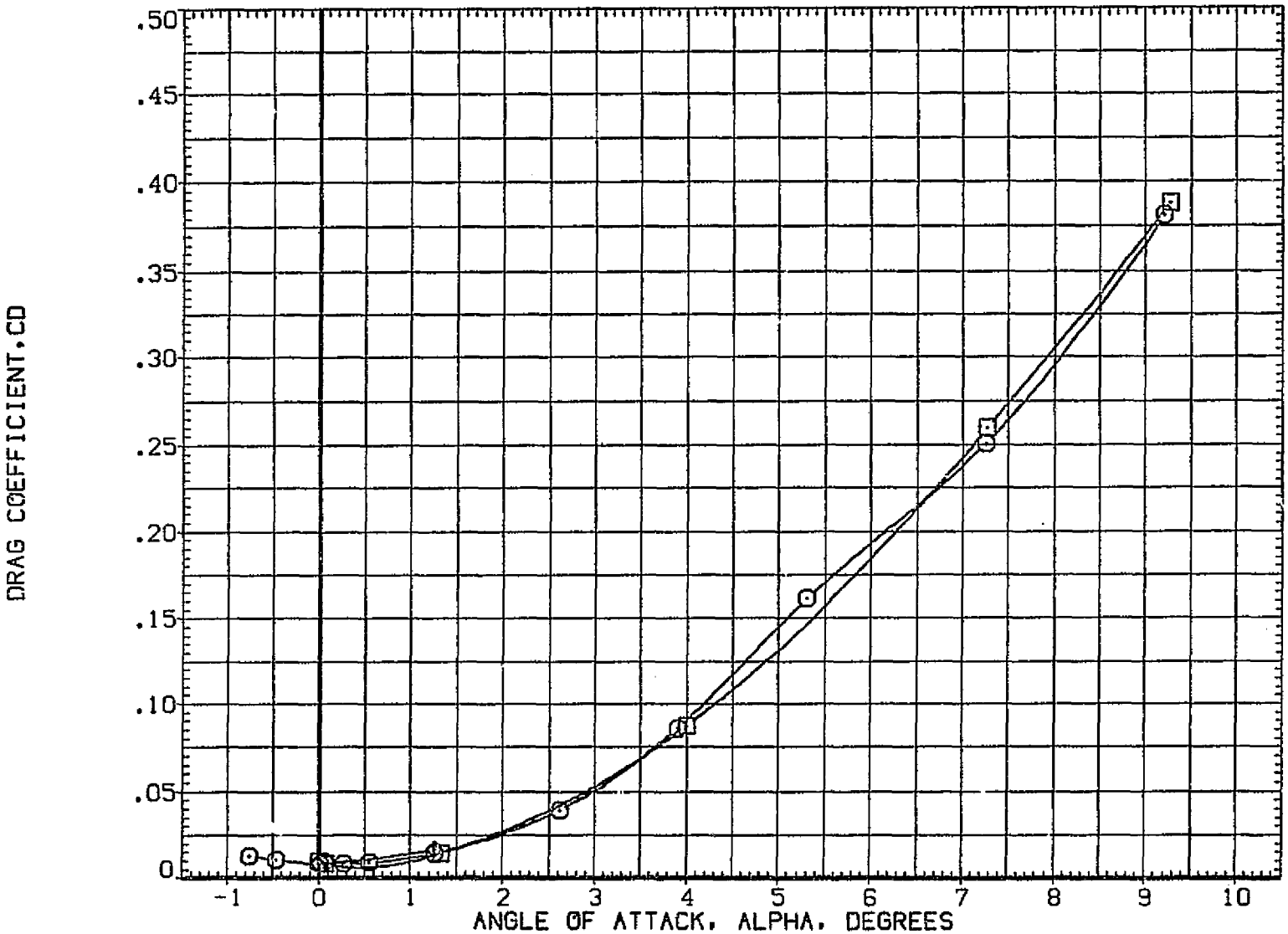

FIG. 9 BASIC DATA, SECTION COEFFICIENTS IN FREON 12

SYMBOL	MACH		PARAMETRIC VALUES
○	.595	RN	6.300
□	.618		
◇	.786		

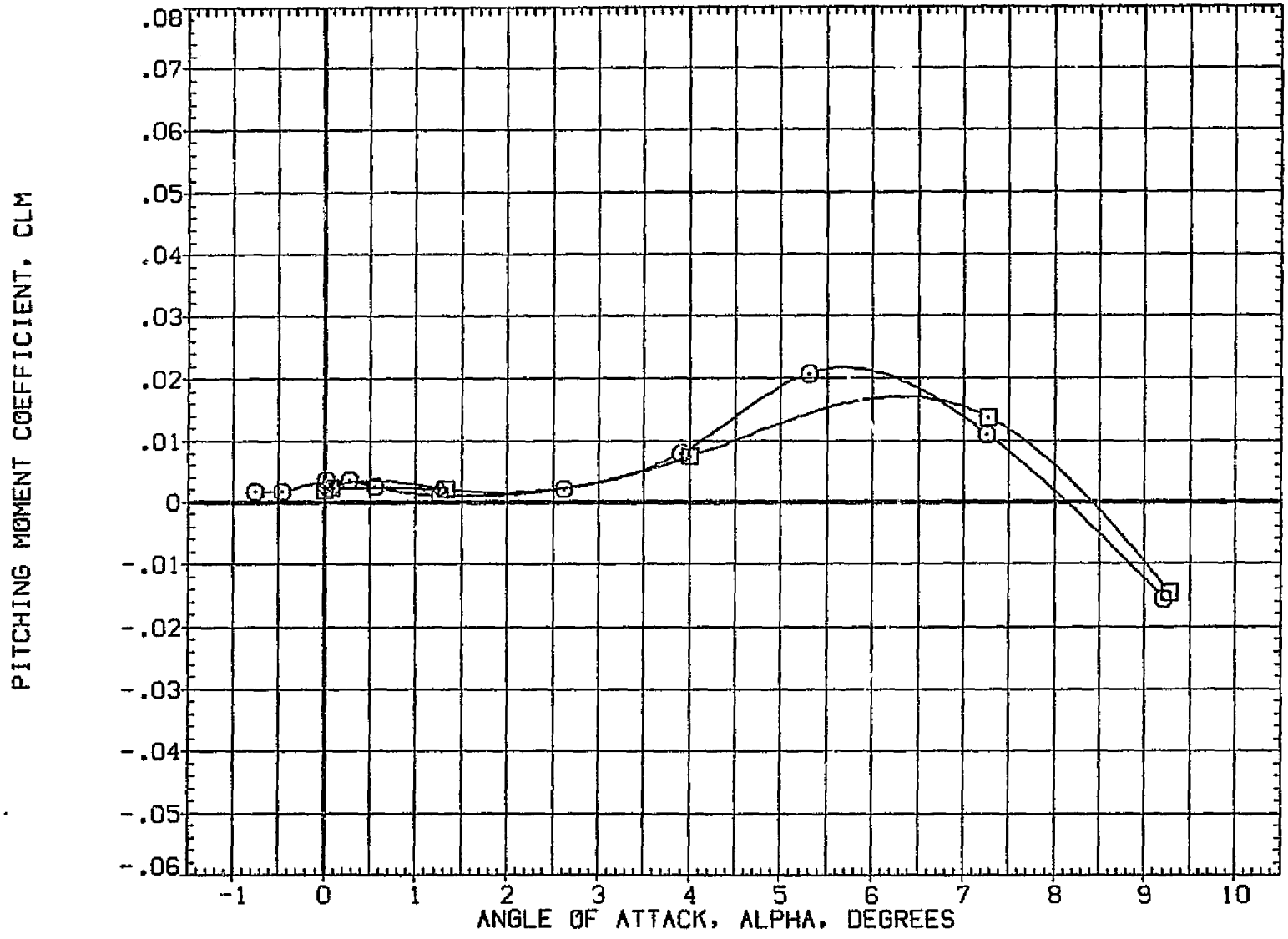

FIG. 9 BASIC DATA, SECTION COEFFICIENTS IN FREON 12

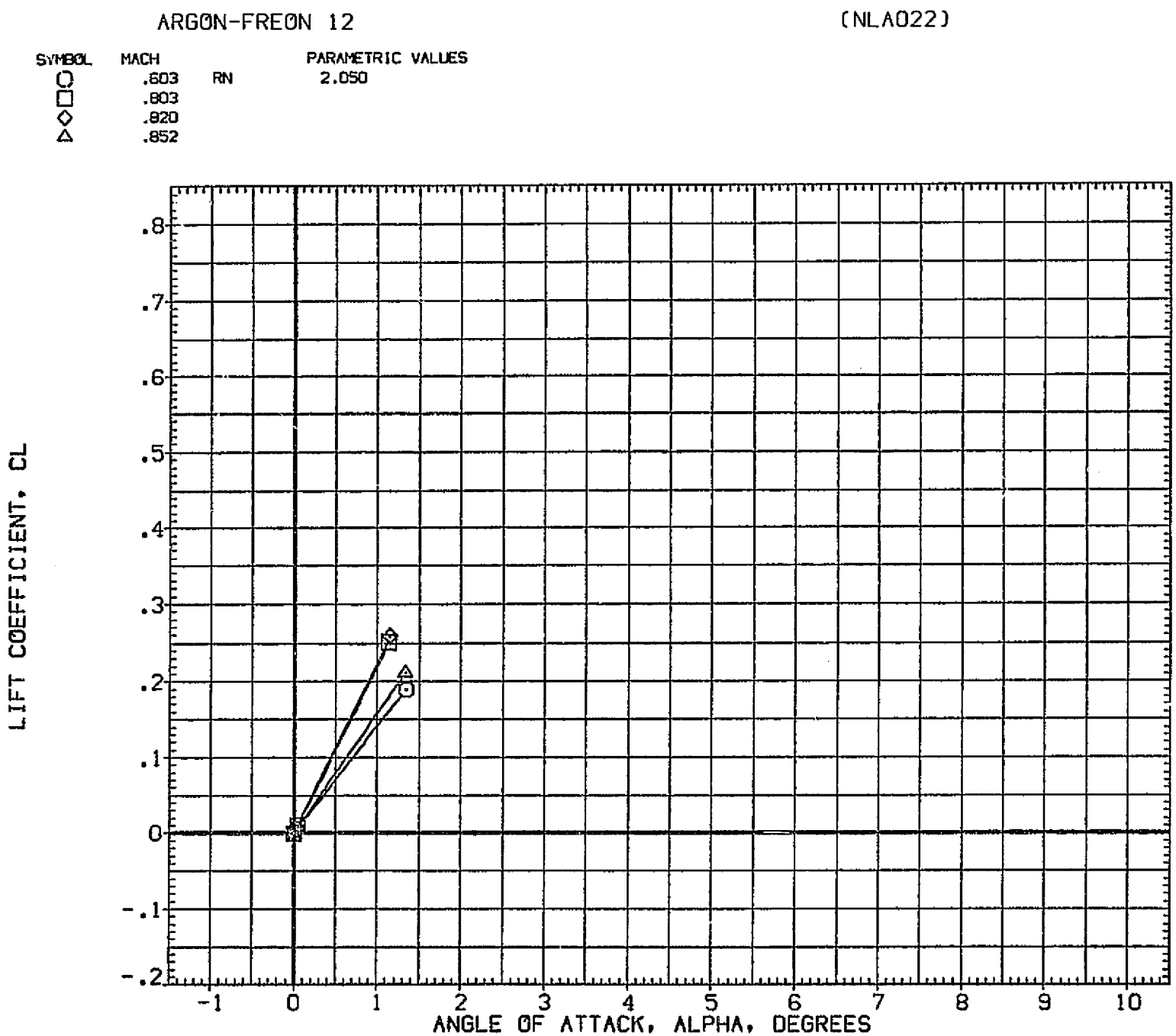

FIG. 10 BASIC DATA, SECTION COEFFICIENTS IN ARGON-FREON 12

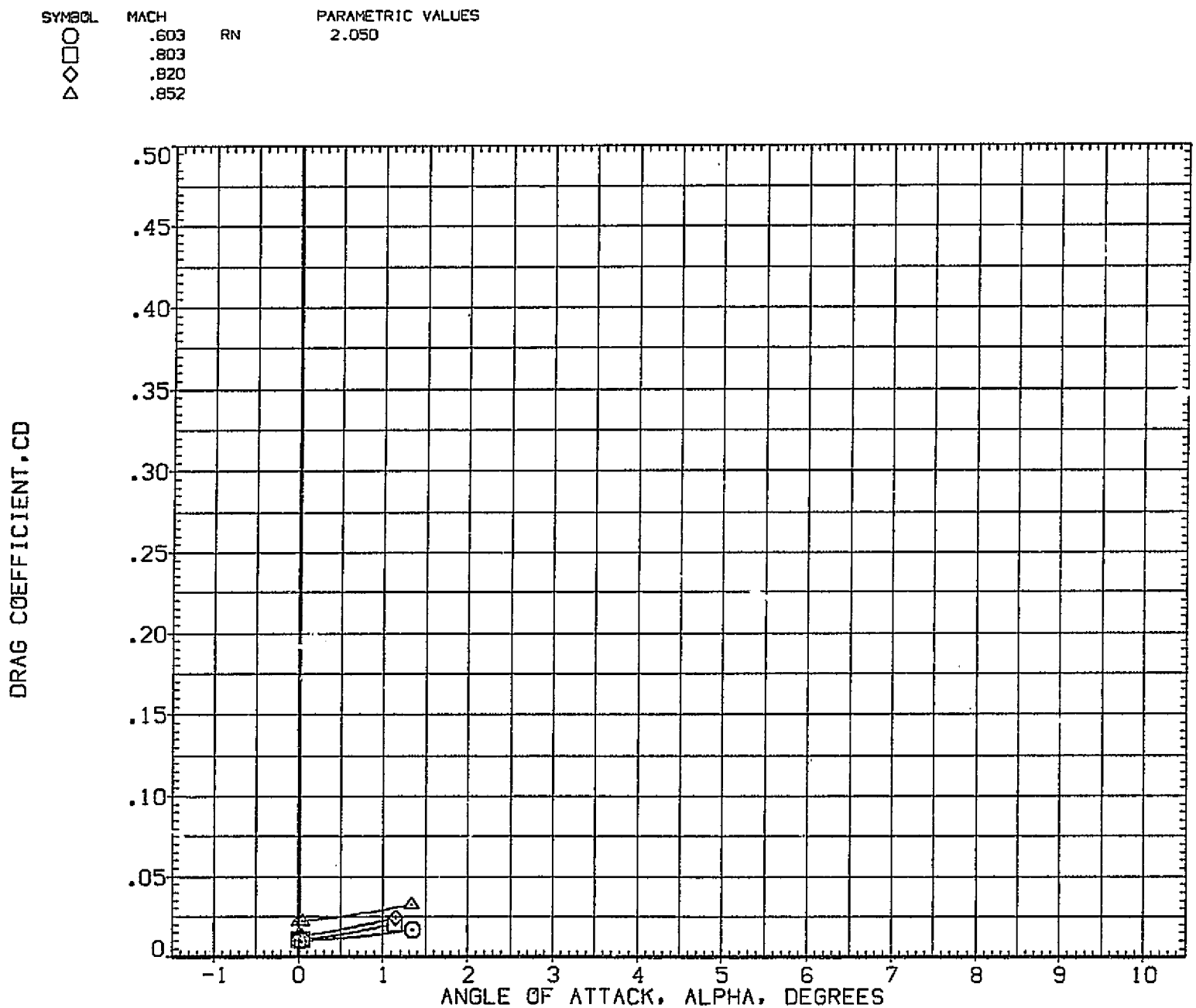

FIG. 10 BASIC DATA, SECTION COEFFICIENTS IN ARGON-FREON 12

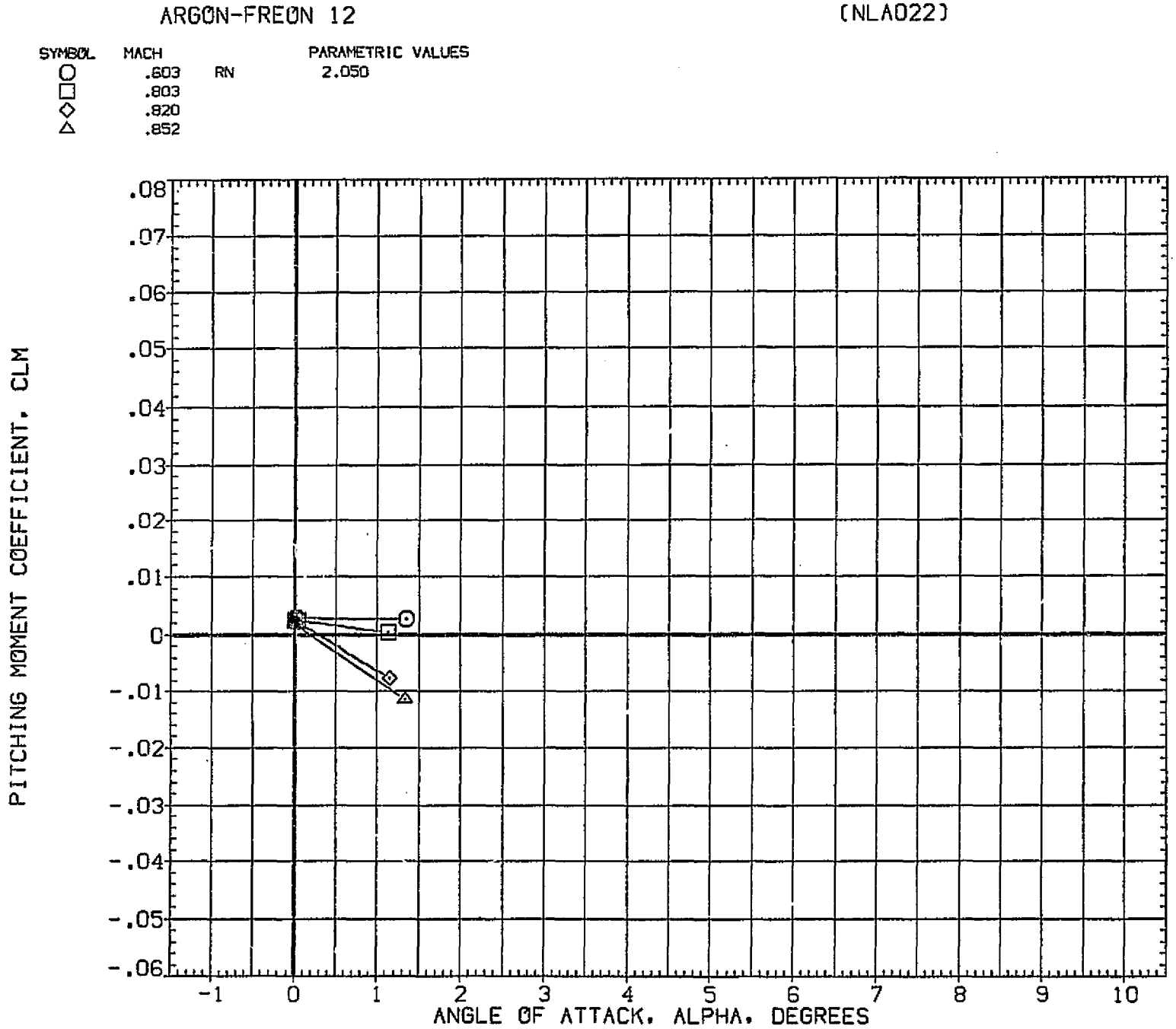

FIG. 10 BASIC DATA, SECTION COEFFICIENTS IN ARGON-FREON 12

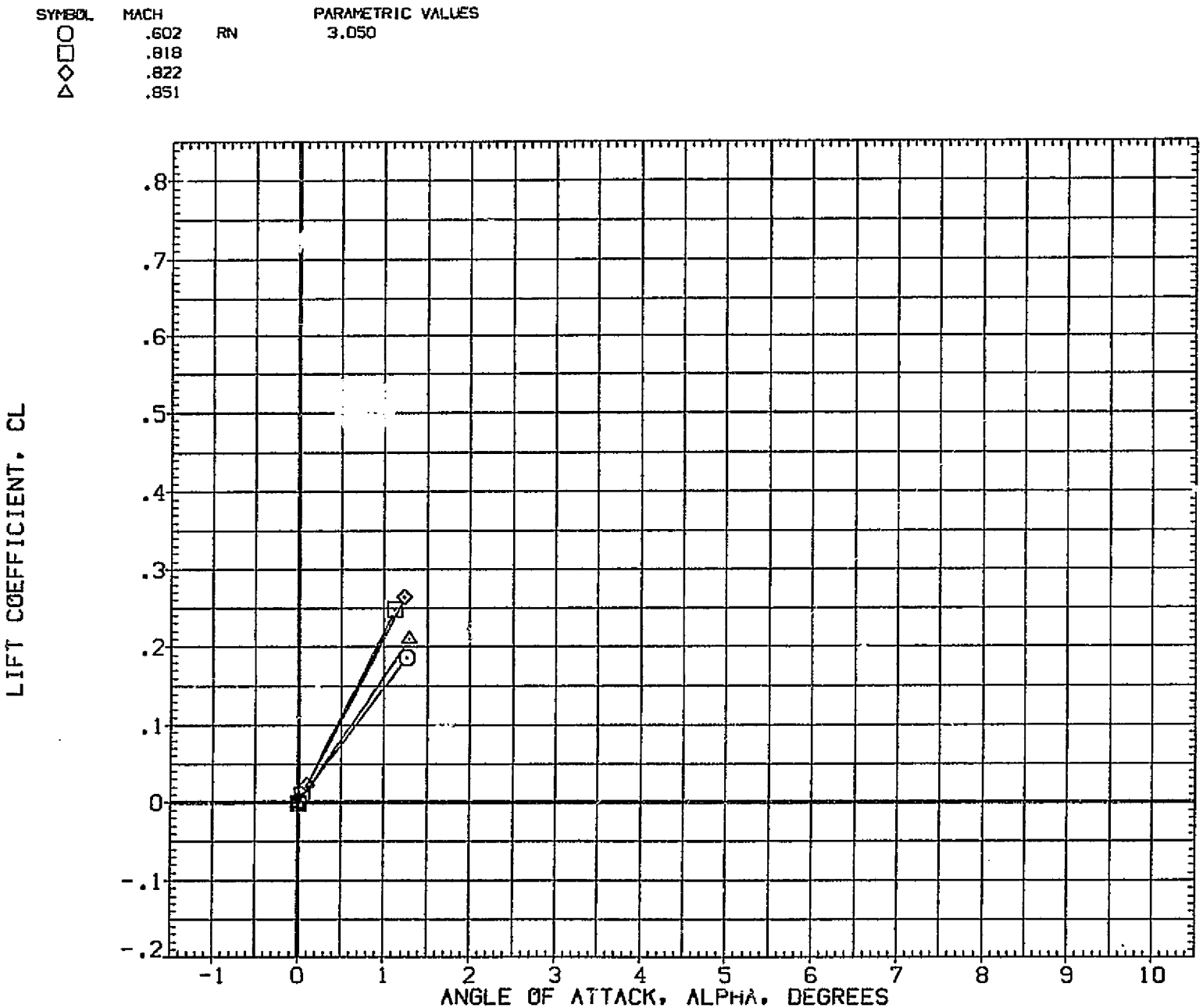

FIG. 10 BASIC DATA, SECTION COEFFICIENTS IN ARGON-FREON 12

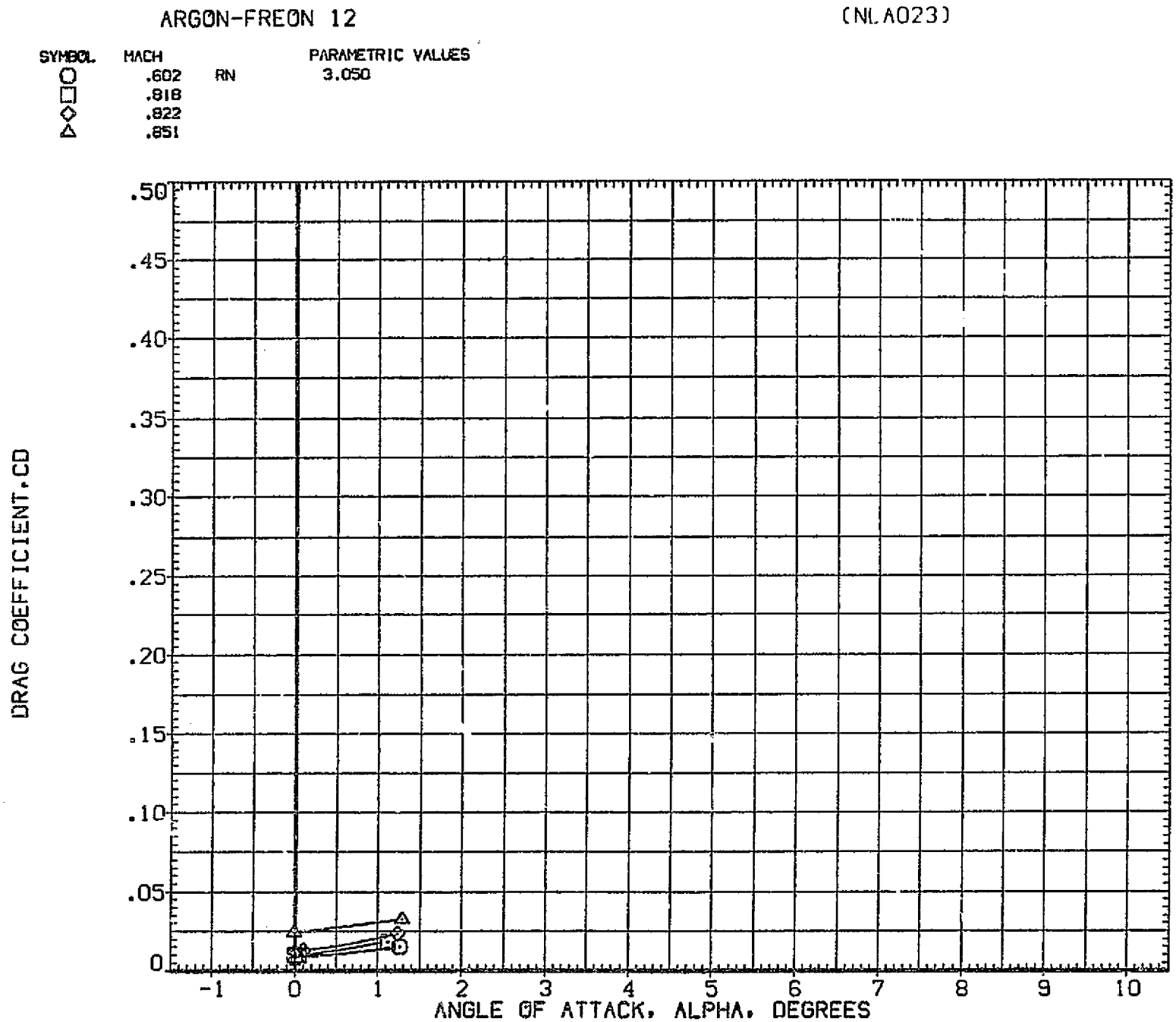

FIG. 10 BASIC DATA, SECTION COEFFICIENTS IN ARGON-FREON 12

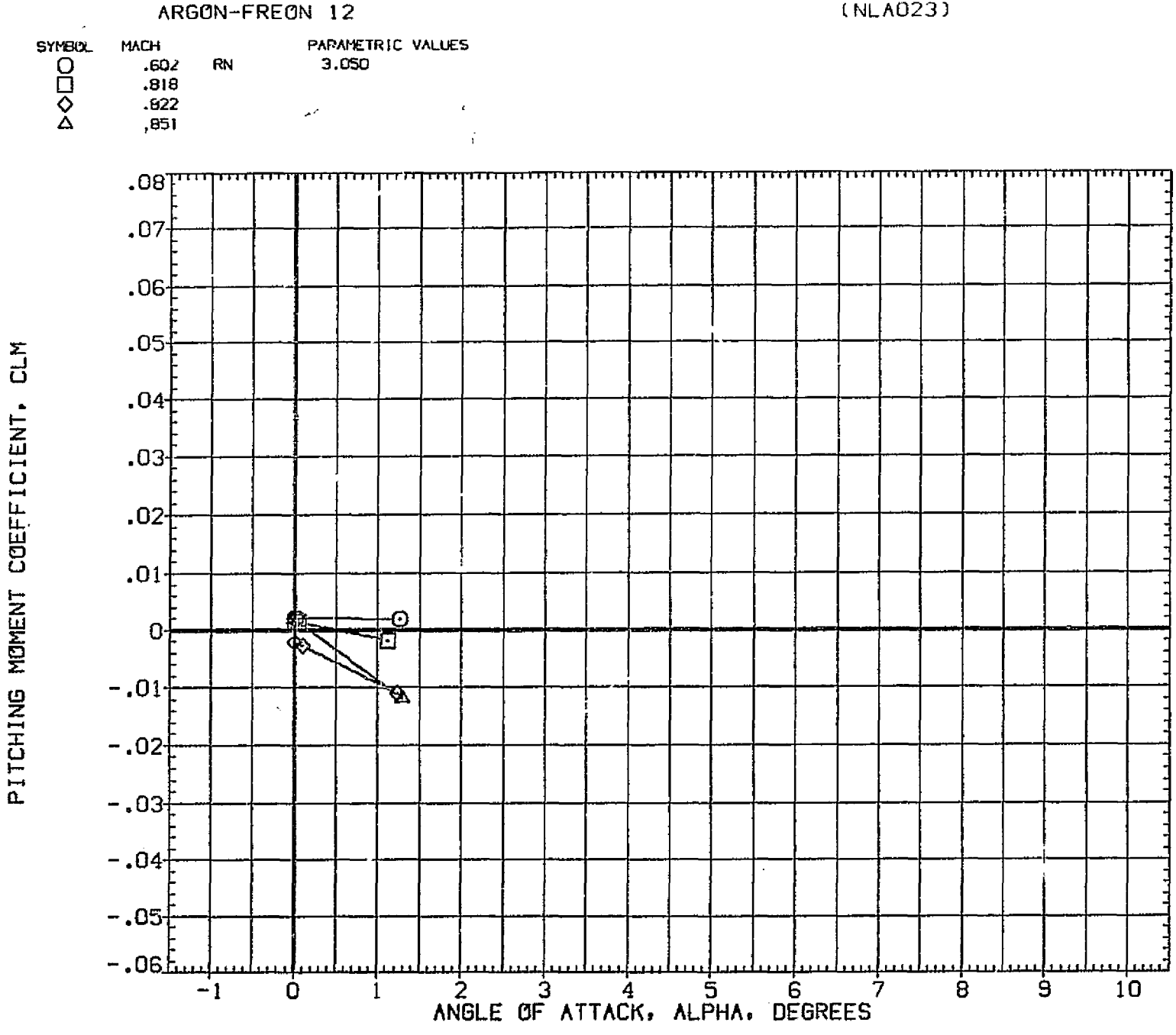

FIG. 10 BASIC DATA, SECTION CØEFFICIENTS IN ARGØN-FREØN 12

DATA SET	SYMBOL	CONFIGURATION	DESCRIPTION	RN	MACH
(BLA603)	□	AIR	AIRFOIL UPPER SURFACE	3.000	.602
(BLA615)	◇	ARGON	AIRFOIL UPPER SURFACE	3.000	.603
(DLA603)	⊠	AIR	AIRFOIL LOWER SURFACE	3.000	.602
(DLA615)	⊠	ARGON	AIRFOIL LOWER SURFACE	3.000	.603

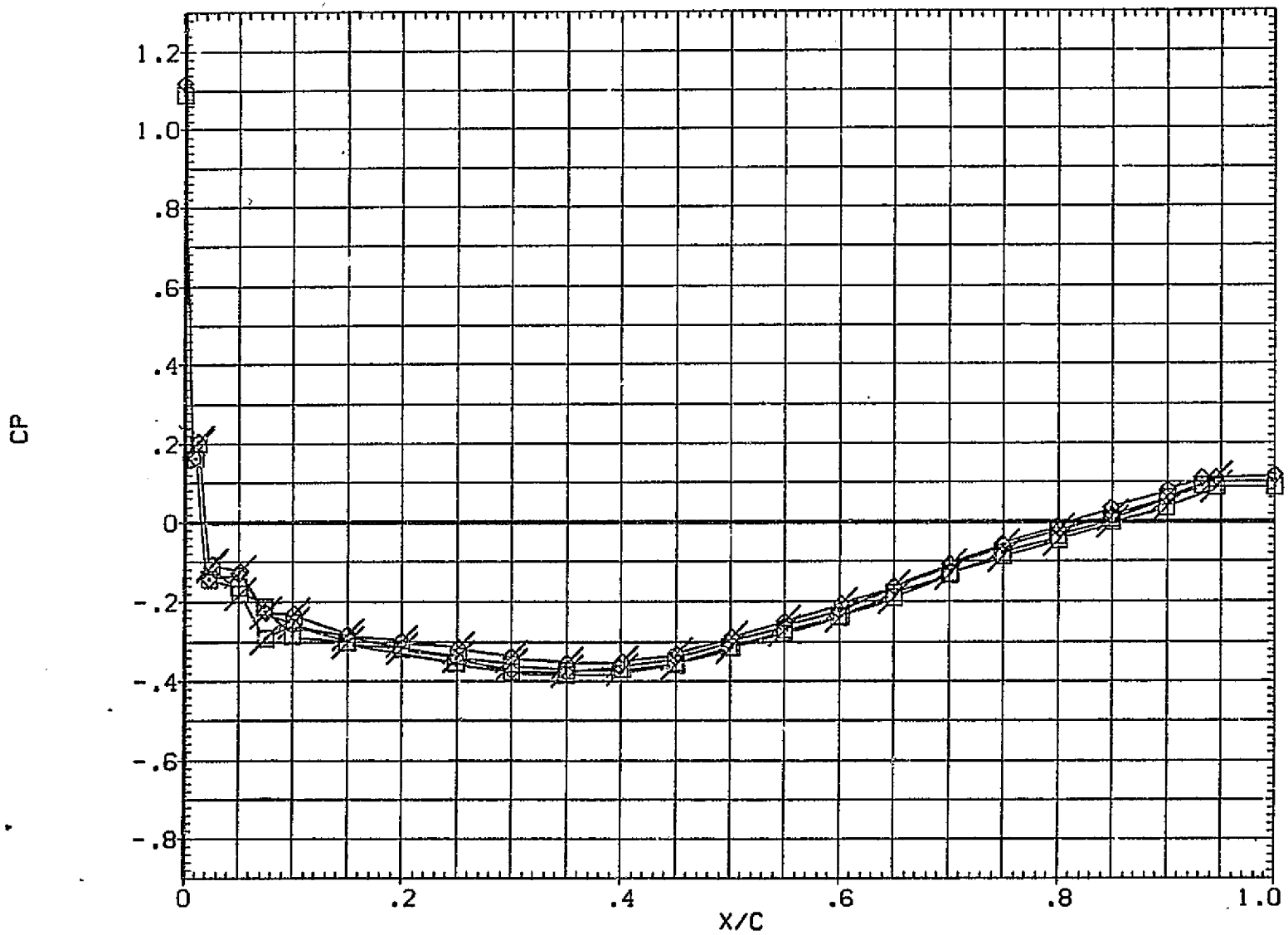

FIG. 11 COMPARISON DATA, PRESSURE DISTRIBUTIONS AIR VS. ARGON

MACH = .600 ALPHA = .000 Y = .000

DATA SET SYMBOL	CONFIGURATION	DESCRIPTION	RN	MACH
(BLA803)	AIR	AIRFOIL UPPER SURFACE	3.000	.832
(BLA815)	ARGON	AIRFOIL UPPER SURFACE	3.000	.829
(DLA803)	AIR	AIRFOIL LOWER SURFACE	3.000	.832
(DLA815)	ARGON	AIRFOIL LOWER SURFACE	3.000	.829

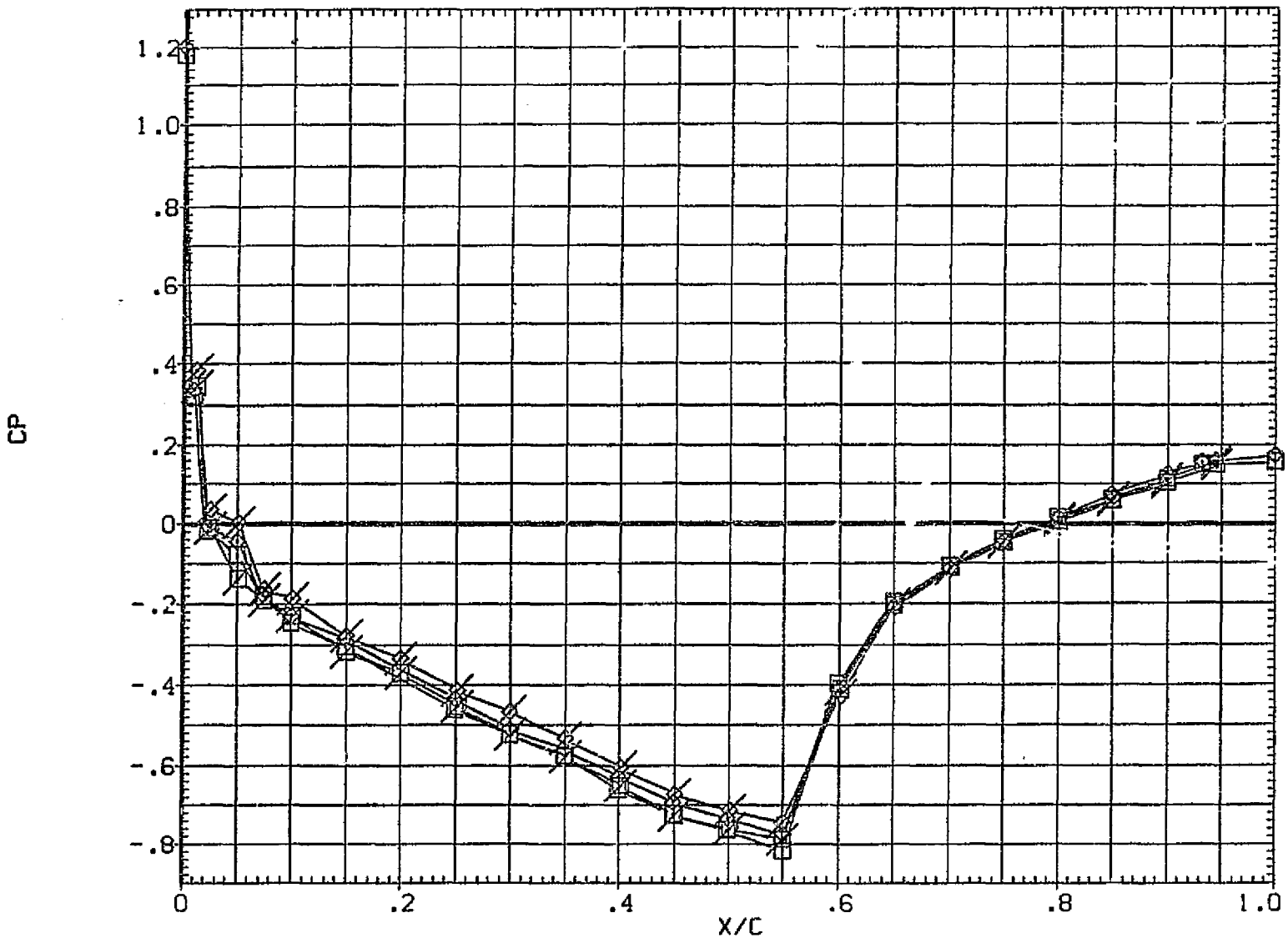

FIG. 11 COMPARISON DATA, PRESSURE DISTRIBUTIONS AIR VS. ARGON

MACH = .830 ALPHA = .000 Y = .000

DATA SET	SYMBOL	CONFIGURATION	DESCRIPTION	RN	MACH
(BLA603)	□	AIR	AIRFOIL UPPER SURFACE	3.000	.602
(BLA624)	◇	FREON 12	AIRFOIL UPPER SURFACE	2.900	.593
(DLA603)	⊠	AIR	AIRFOIL LOWER SURFACE	3.000	.602
(DLAA24)	⊗	FREON 12	AIRFOIL LOWER SURFACE	2.900	.593

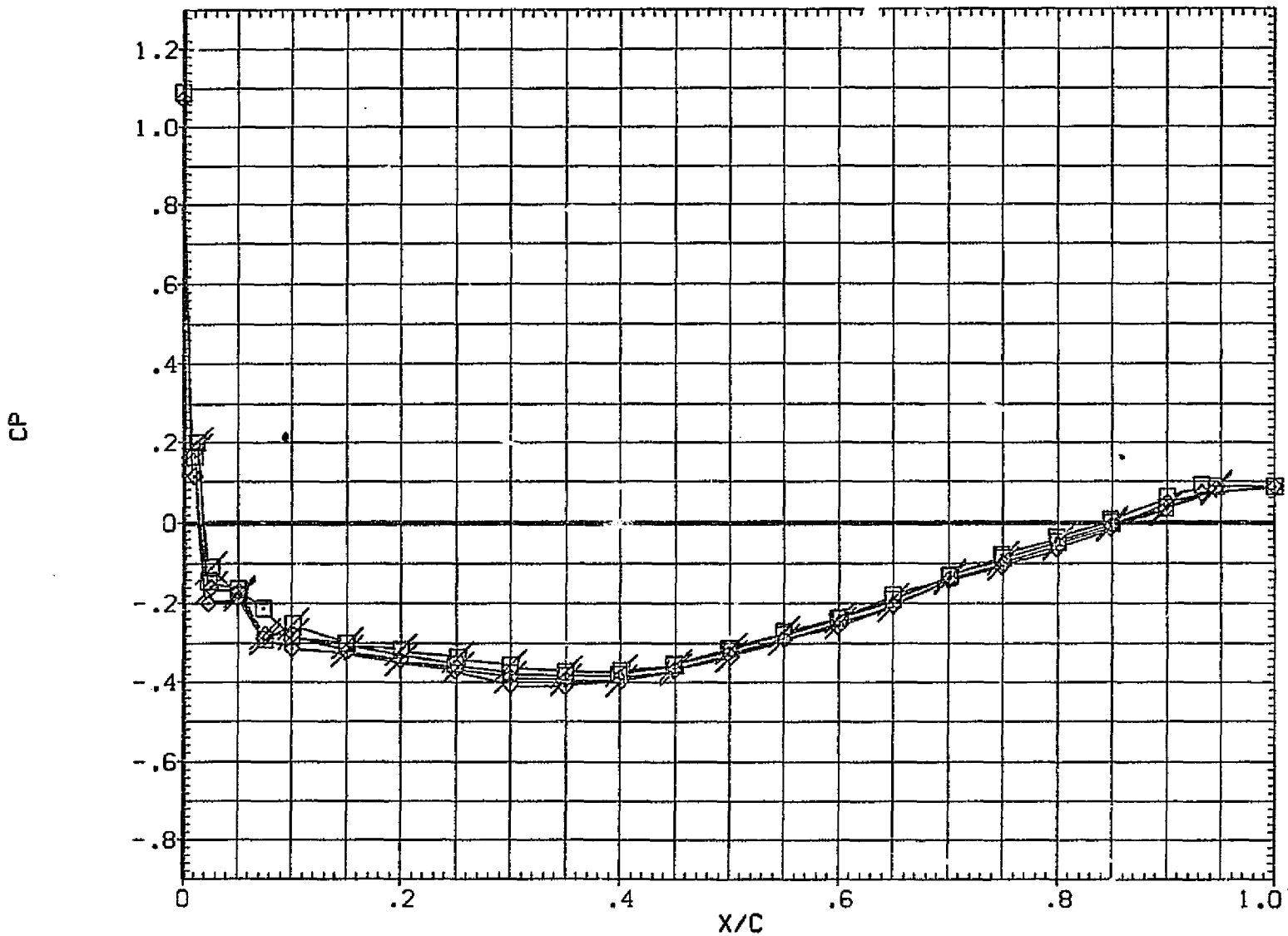

FIG. 12 COMPARISON DATA, PRESSURE DISTRIBUTIONS AIR VS. FREON 12

MACH = .600 ALPHA = .000 Y = .000

DATA SET	SYMBOL	CONFIGURATION	DESCRIPTION	RN	MACH
(BLA823)	□	AIR	AIRFOIL UPPER SURFACE	3.000	.820
(BLA826)	◇	FREON 12	AIRFOIL UPPER SURFACE	2.850	.823
(DLA823)	⊠	AIR	AIRFOIL LOWER SURFACE	3.000	.820
(DLA826)	⊘	FREON 12	AIRFOIL LOWER SURFACE	2.850	.823

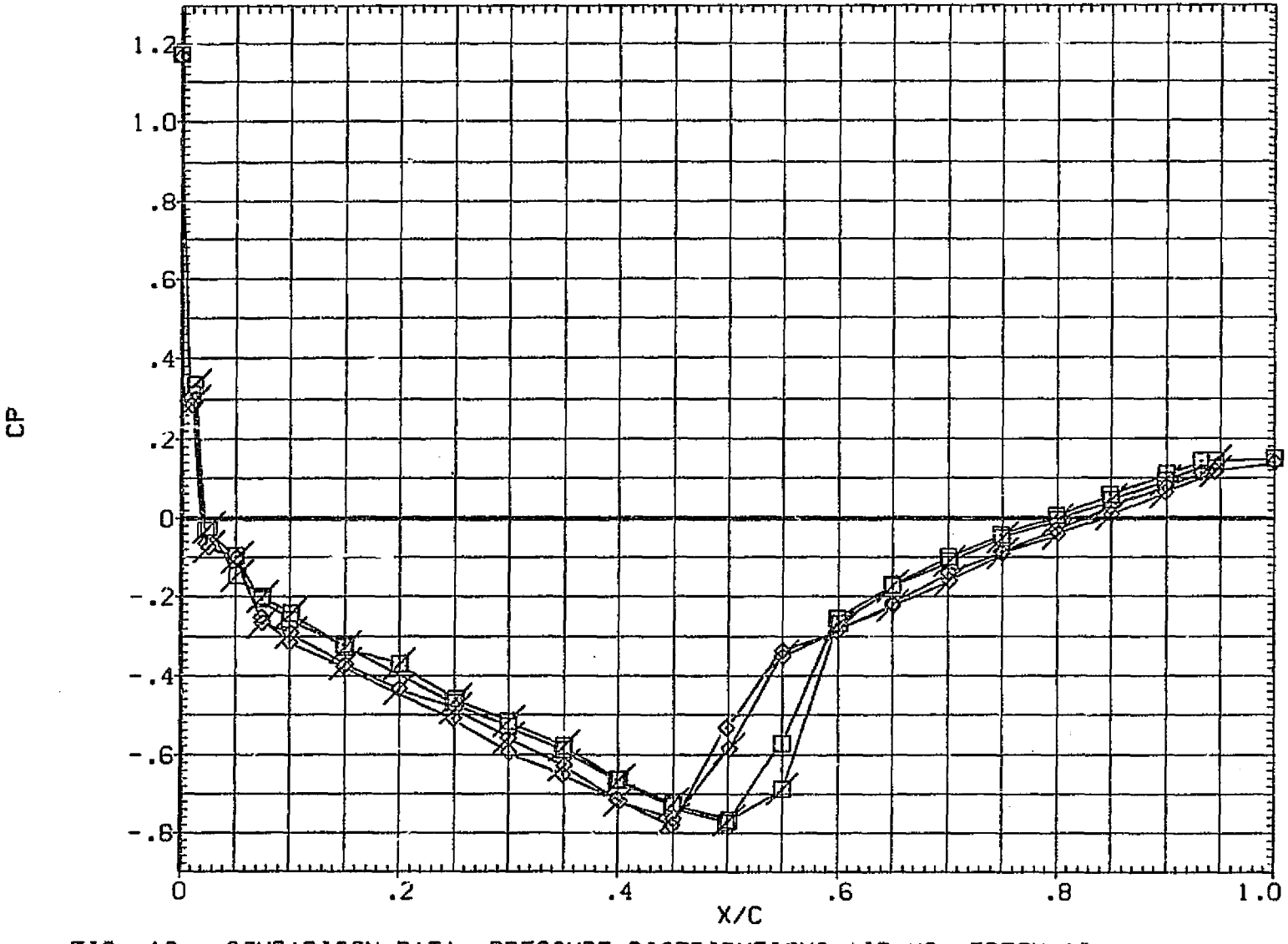

FIG. 12 COMPARISON DATA, PRESSURE DISTRIBUTIONS AIR VS. FREON 12

MACH = .820 ALPHA = .000 Y = .000

DATA SET	SYMBOL	CONFIGURATION	DESCRIPTION	RN	MACH
(BLA803)	□	AIR	AIRFOIL UPPER SURFACE	3.000	.832
(BLA843)	◇	FREON 12	AIRFOIL UPPER SURFACE	2.900	.843
(DLA803)	⊠	AIR	AIRFOIL LOWER SURFACE	3.000	.832
(DLA843)	⊗	FREON 12	AIRFOIL LOWER SURFACE	2.900	.843

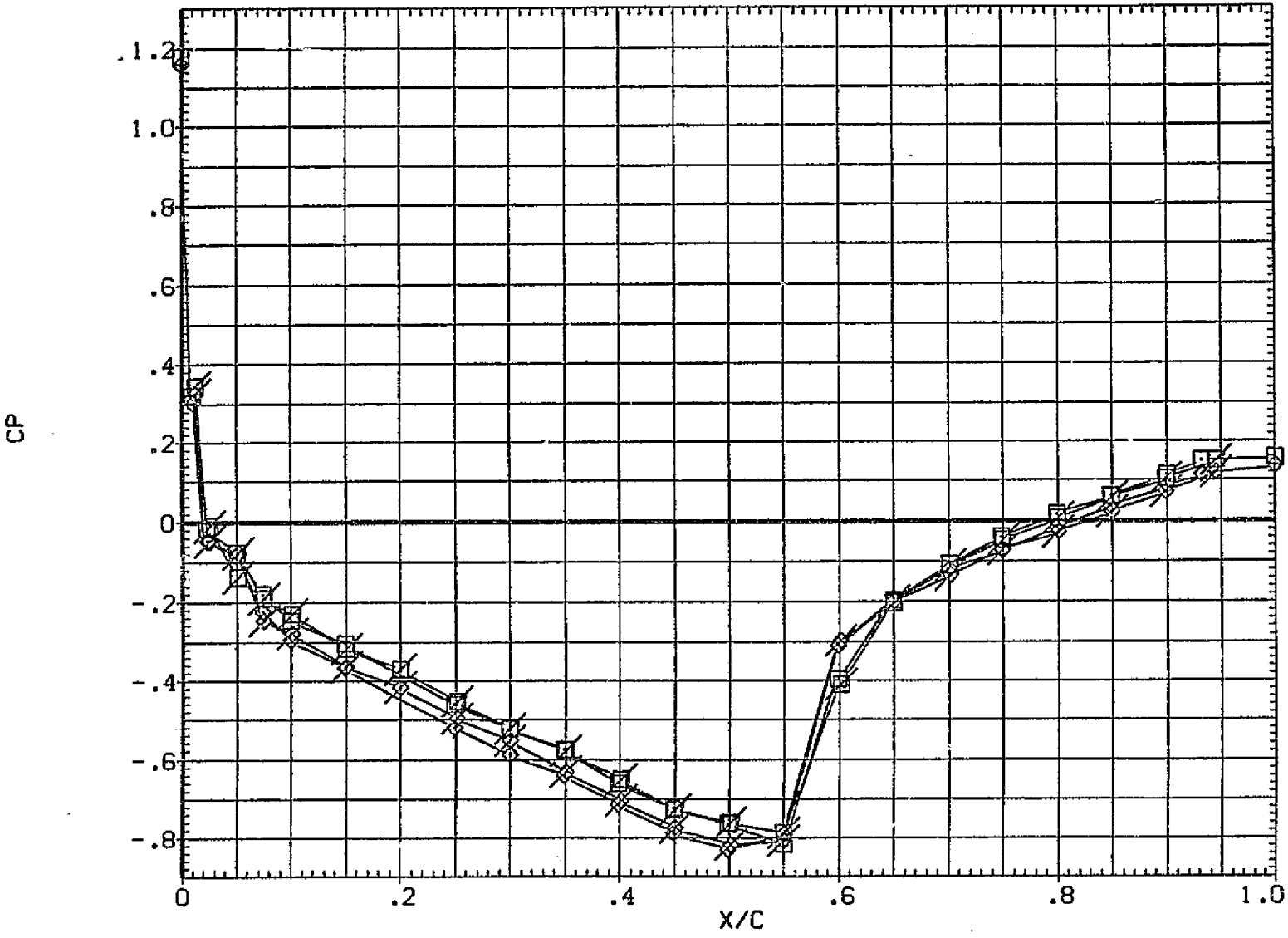

FIG. 13A COMPARISON DATA, AIR VS. FREON 12 (TRANSONIC SIMILARITY MACH NUMBER)

MACH = .830 ALPHA = .000 Y = .000

DATA SET	SYMBOL	CONFIGURATION	DESCRIPTION	RN	MACH
(BLA803)	□	AIR	AIRFOIL UPPER SURFACE	3.000	.832
(CLAA24)	◇	FREON 12	AIRFOIL UPPER SURFACE	2.900	.843
(BLA803)	▨	AIR	AIRFOIL LOWER SURFACE	3.000	.832
(CLAB24)	▨	FREON 12	AIRFOIL LOWER SURFACE	2.900	.843

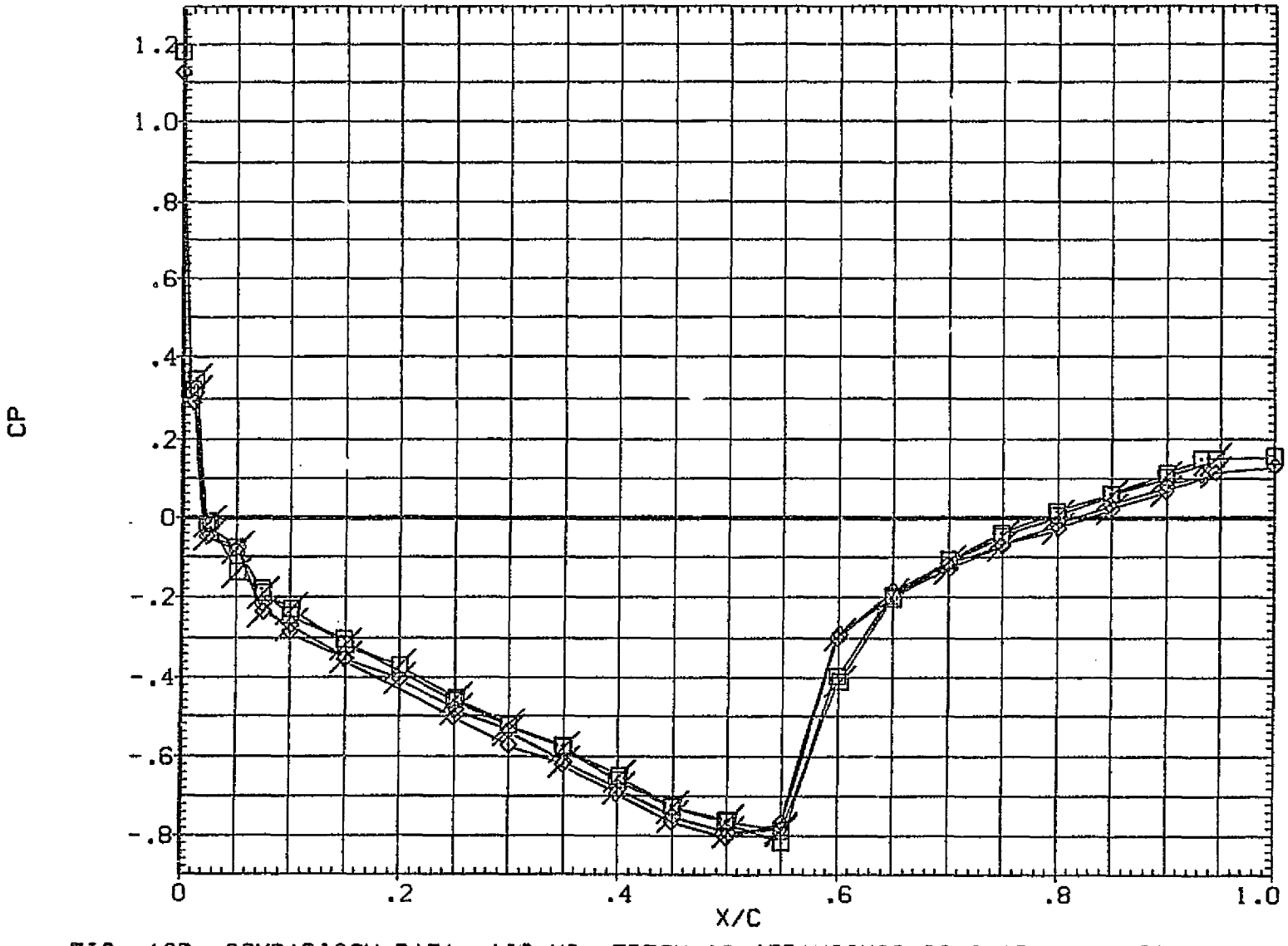

FIG. 13B COMPARISON DATA, AIR VS. FREON 12 (TRANSONIC SIMILARITY RULE)

MACH = .830 ALPHA = .000 Y = .000

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION		RN	MACH
(CLAA01)	□	AIR	AIRFOIL UPPER SURFACE	2.000	.800
(CLAA22)	◇	ARGON-FREON 12	AIRFOIL UPPER SURFACE	2.050	.802
(CLAB01)	▽	AIR	AIRFOIL LOWER SURFACE	2.000	.800
(CLAB22)	⊘	ARGON-FREON 12	AIRFOIL LOWER SURFACE	2.050	.802

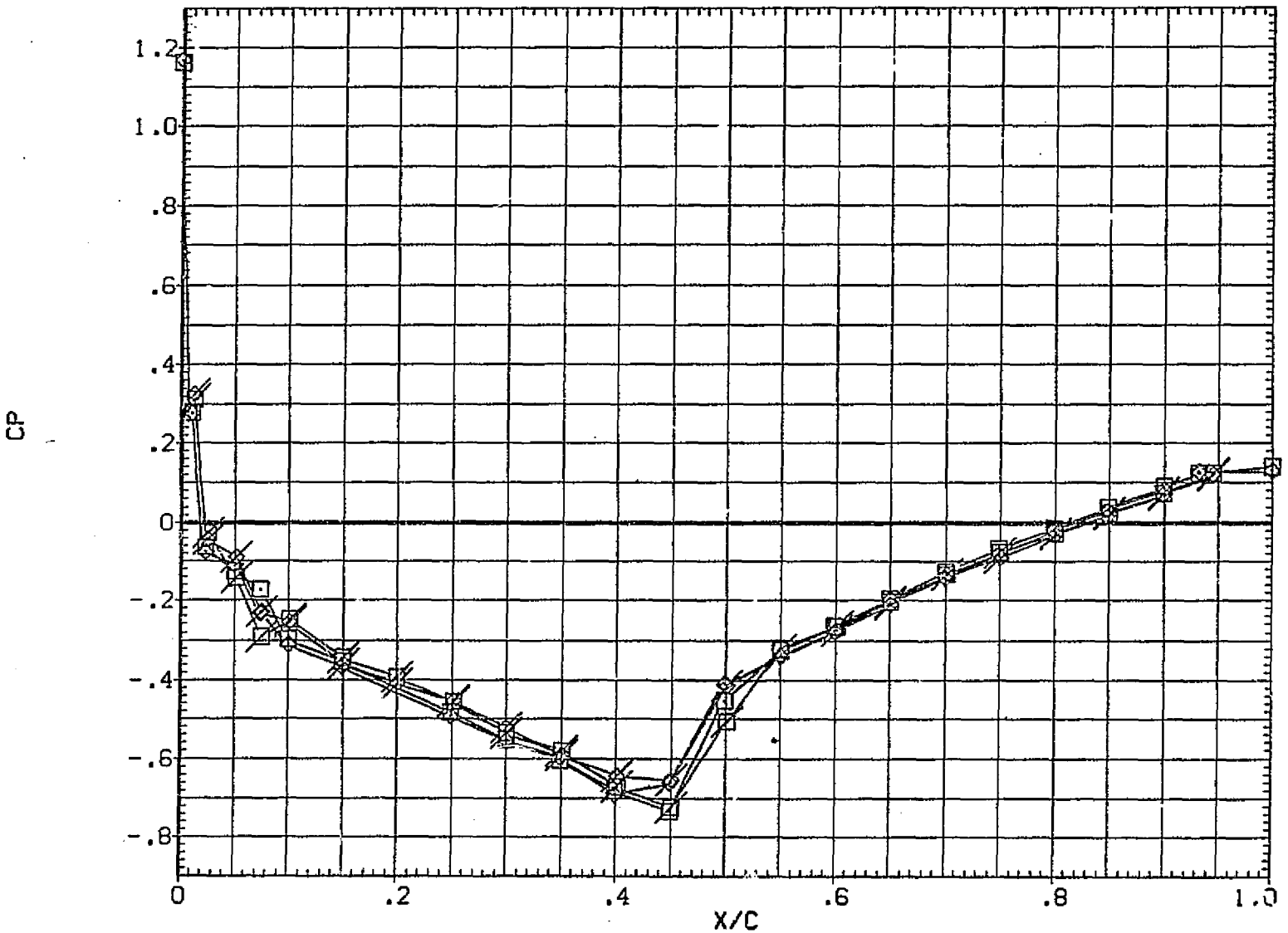

FIG. 14 COMPARISON DATA, PRESSURE DISTRIBUTIONS AIR VS. ARGON-FREON12

MACH = .900 ALPHA = .000 Y = .000

DATA SET SYMBOL	CONFIGURATION DESCRIPTION	RN
(FLA003)	AIR	3.000
(CLA015)	ARGON	3.000
(HLA024)	FREON 12	2.900
(CLA023)	ARGON-FREON 12	3.050

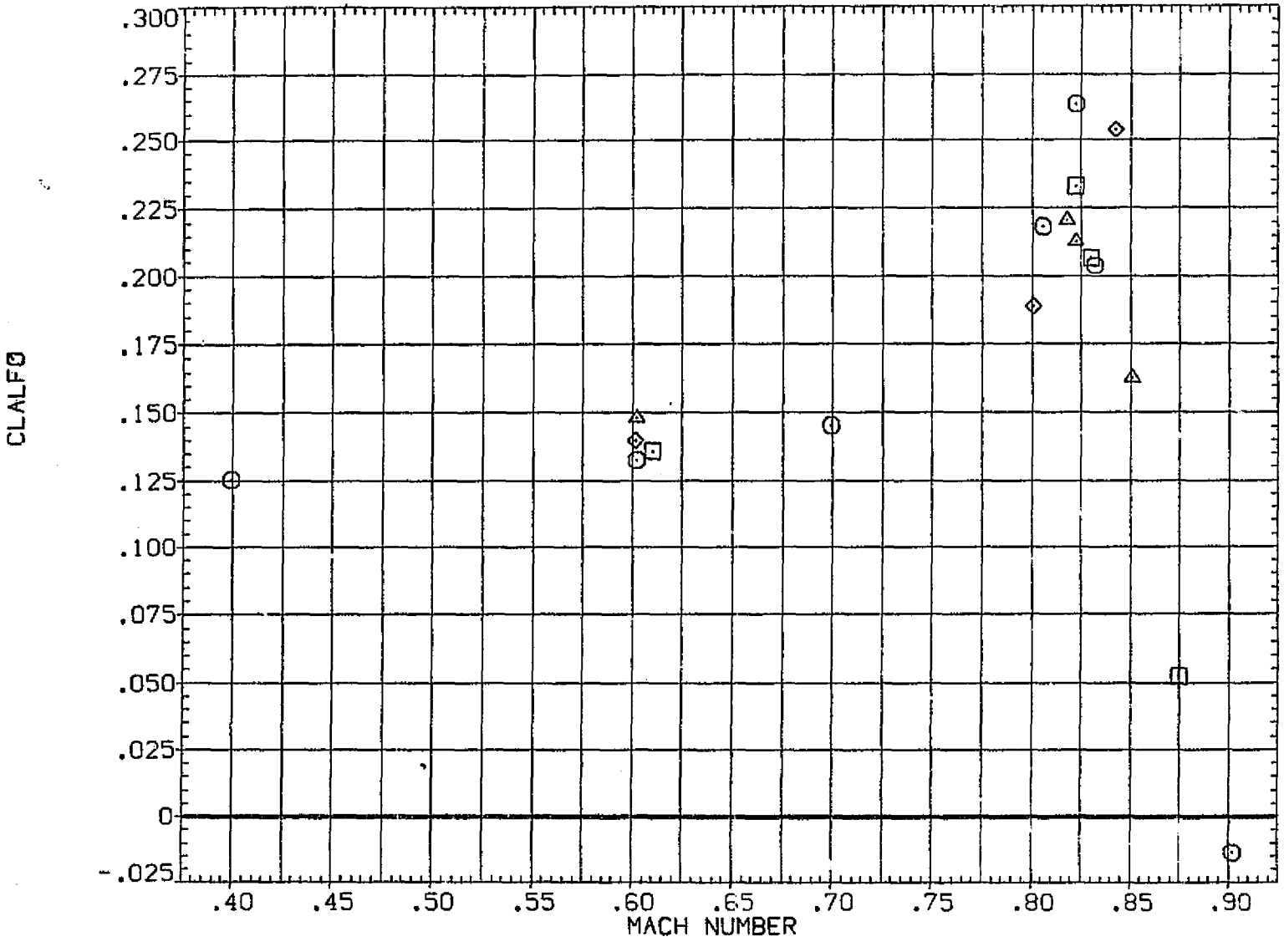

FIG. 15 SUMMARY COMPARISONS, AIR VS. ARGON VS. FREON 12 VS. ARGON-FREON 12

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN
(FLA003)		AIR	3.000
(CLA015)		ARGON	3.000
(HLA024)		FREON 12	2.900
(CLA023)		ARGON-FREON 12	3.050

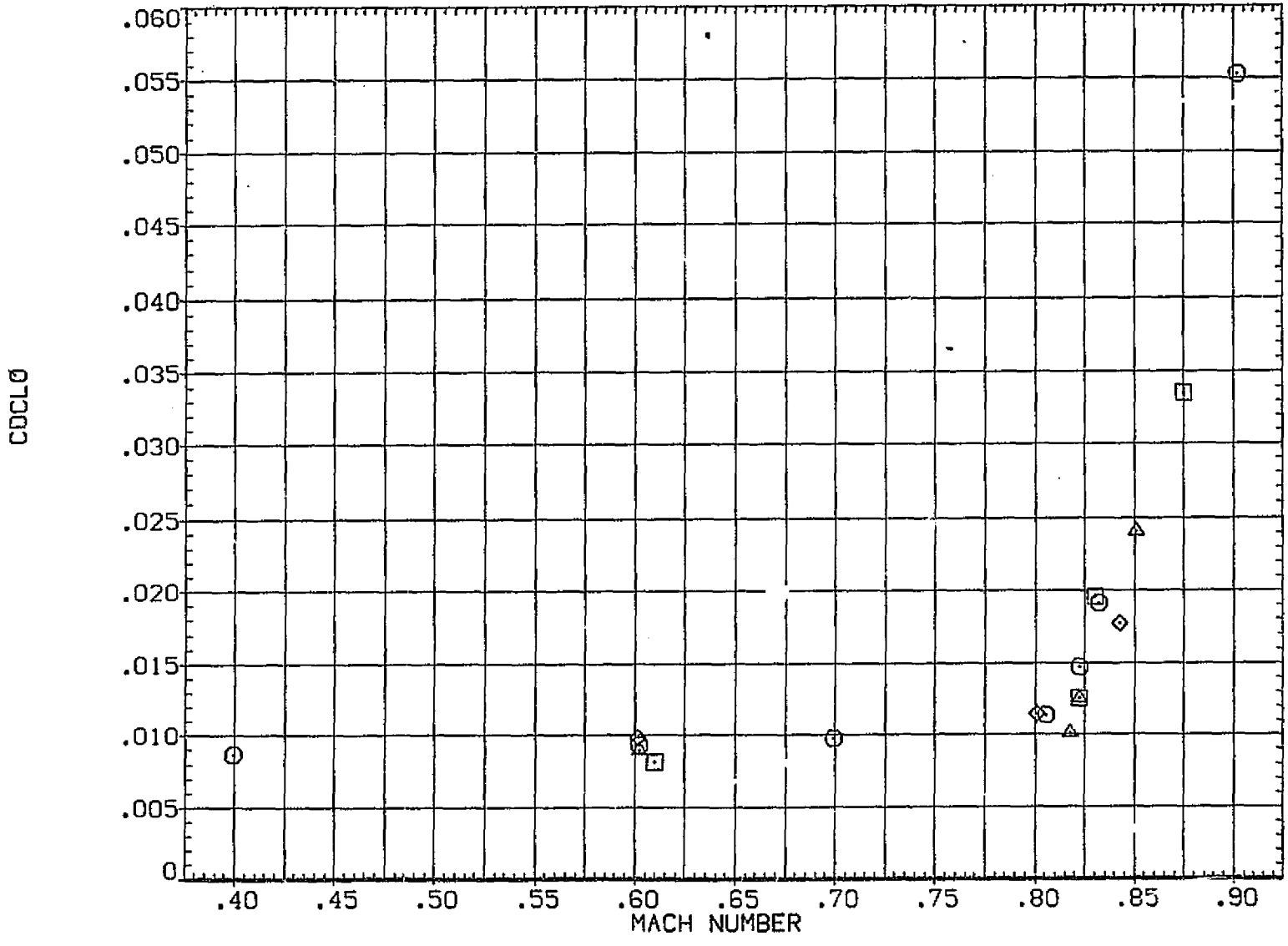

FIG. 15 SUMMARY COMPARISONS, AIR VS. ARGON VS. FREON 12 VS. ARGON-FREON 12